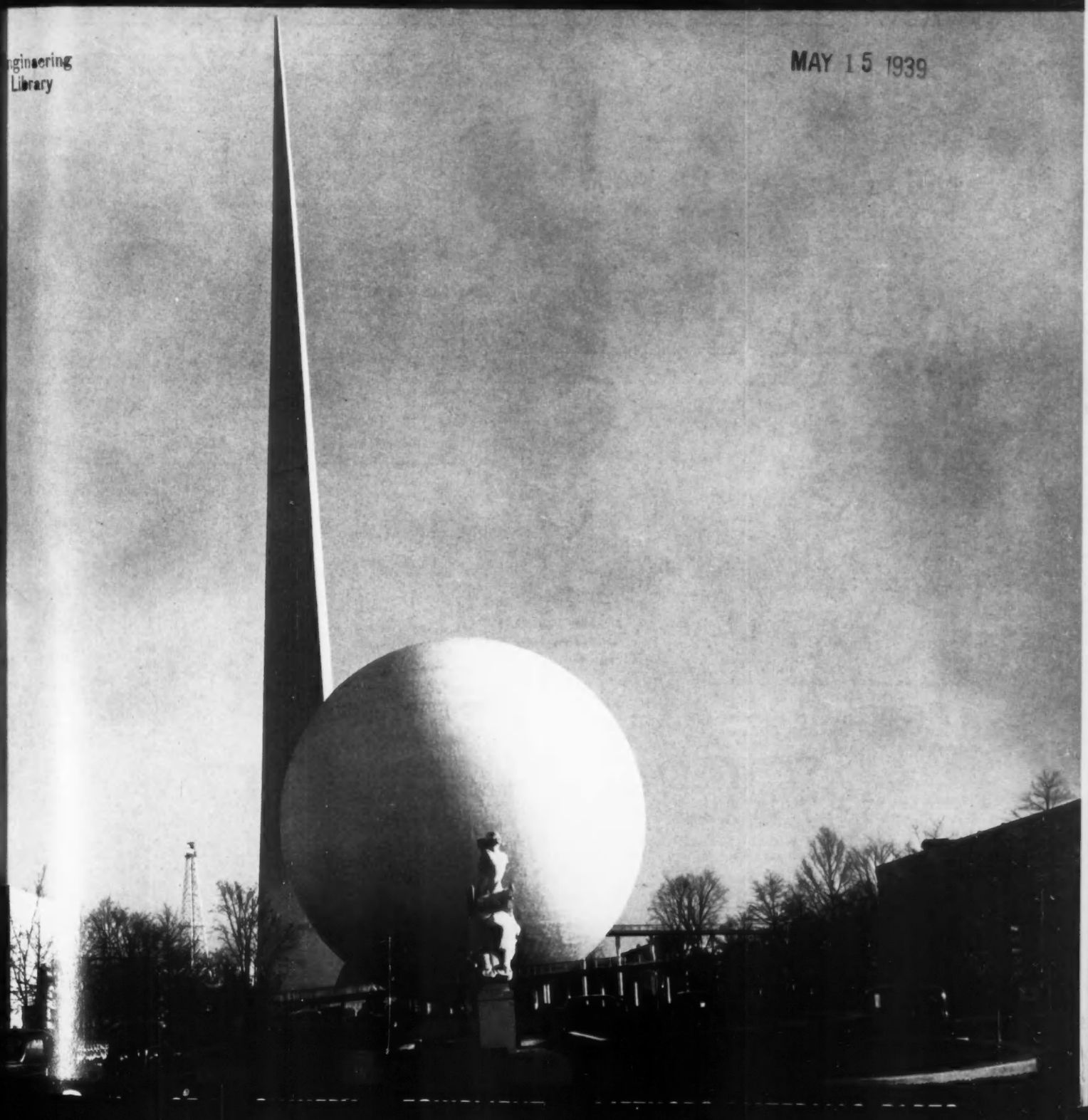
PRODUCT ENGINEERING

MAY, 1939



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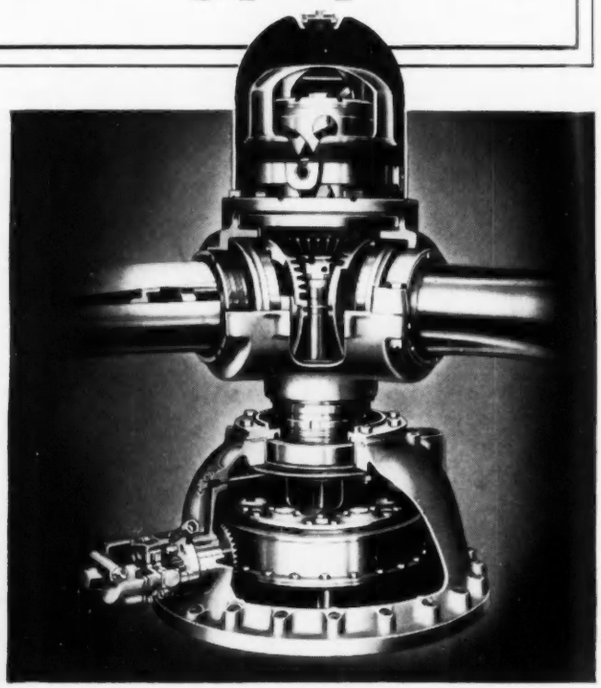
MAY 15 1939

In 1896 *... bicycle chains*

In 1939 *... feathering propellers*

Nickel made both run longer

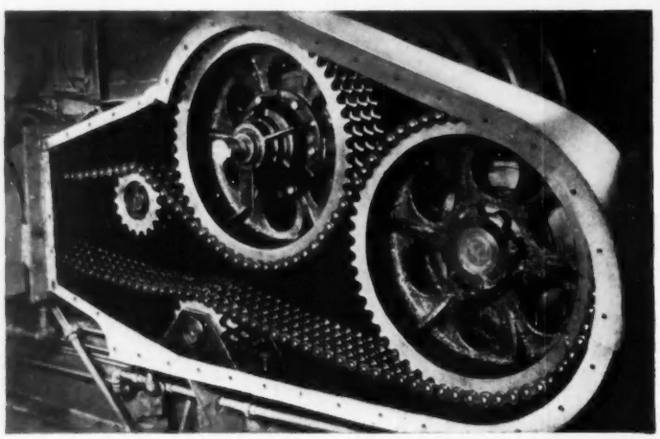


STYLES in steels change, too. Yet among the first commercial users of alloy steels, the Whitney Chain & Mfg. Co., Hartford, still depends upon Nickel alloy steel. In 1896, Whitney built bicycle sprocket chains from 5% Nickel steel. Today's Whitney roller chain industrial drives still include 5% Nickel to assure toughness and wear resistance.

1939 airliners can "shift gears" in mid-air. For this, thank Hamilton Standard engineering which produced Hydromatic feathering hubs, and modern metallurgy which provides heat treated 5% Nickel steels that withstand the stress, shock and crushing loads imposed.

For information about money-saving applications of Nickel in your industry, please write to the address below.

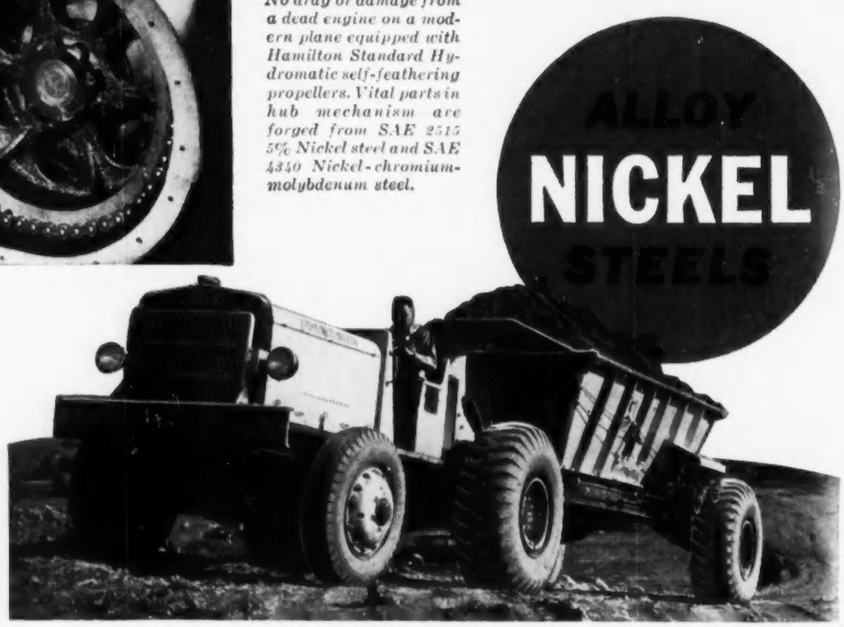
No drag or damage from a dead engine on a modern plane equipped with Hamilton Standard Hydromatic self-feathering propellers. Vital parts in hub mechanism are forged from SAE 2515 5% Nickel steel and SAE 4340 Nickel-chromium-molybdenum steel.



43 years of Nickel alloy steel experience is back of this Whitney roller chain. Whitney engineers use a special 5% Nickel alloy steel similar to SAE 2515 or 2520 for wear-resisting pins. Strong, shock-resisting side links are Nickel-chromium steel, SAE 3140. Rollers are SAE 3130, bushings SAE 3115 Nickel-chromium steels.

• • •

Can your trucks haul 18 tons uphill over rough ground? Euclid Trac-Truks do move such payloads at low cost because vital parts, from engine to trailer axle, are made lighter yet stronger by using Nickel alloyed materials. These uniformly tough ductile steels are heat treated to develop the most useful combination of mechanical properties for this service.



THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

PRODUCT ENGINEERING

What's Coming—June *P.E.* will feature the highlights in the design of the Studebaker Champion. We are indebted to the Studebaker engineers for furnishing us with the engineering reasons that dictated the types of constructions which they adopted. The article will include a detailed analysis of the design methods adopted by Studebaker in creating this outstanding design which is offered to the American automobile buyers in the low-priced field.

Other feature articles will include, "What Is Invention" by H. A. Toulmin, and the concluding installment of the article on electrical contact materials appearing in this number.

June *P.E.* will also include the first complete and authoritative article on the subject of Corprene, the cork-rubber composition.

Cover Picture—New York World's Fair, the World of Tomorrow.

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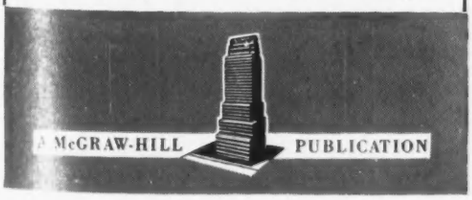

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Syracuse, N. Y.

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EDGERS AND ELECTRIC HAND SAWS
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I trust that future issues of PRODUCT ENGINEERING will be as interesting as the past.

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PROMINENT PRODUCT ENGINEERS HAVE FOUND IT PAYS

PRODUCT ENGINEERING

MAY, 1939 GEORGE F. NORDENHOLT, *Editor* VOLUME TEN, NUMBER FIVE

The Greatest Source for New Ideas

"TO PROMOTE the Progress of Science and Useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."

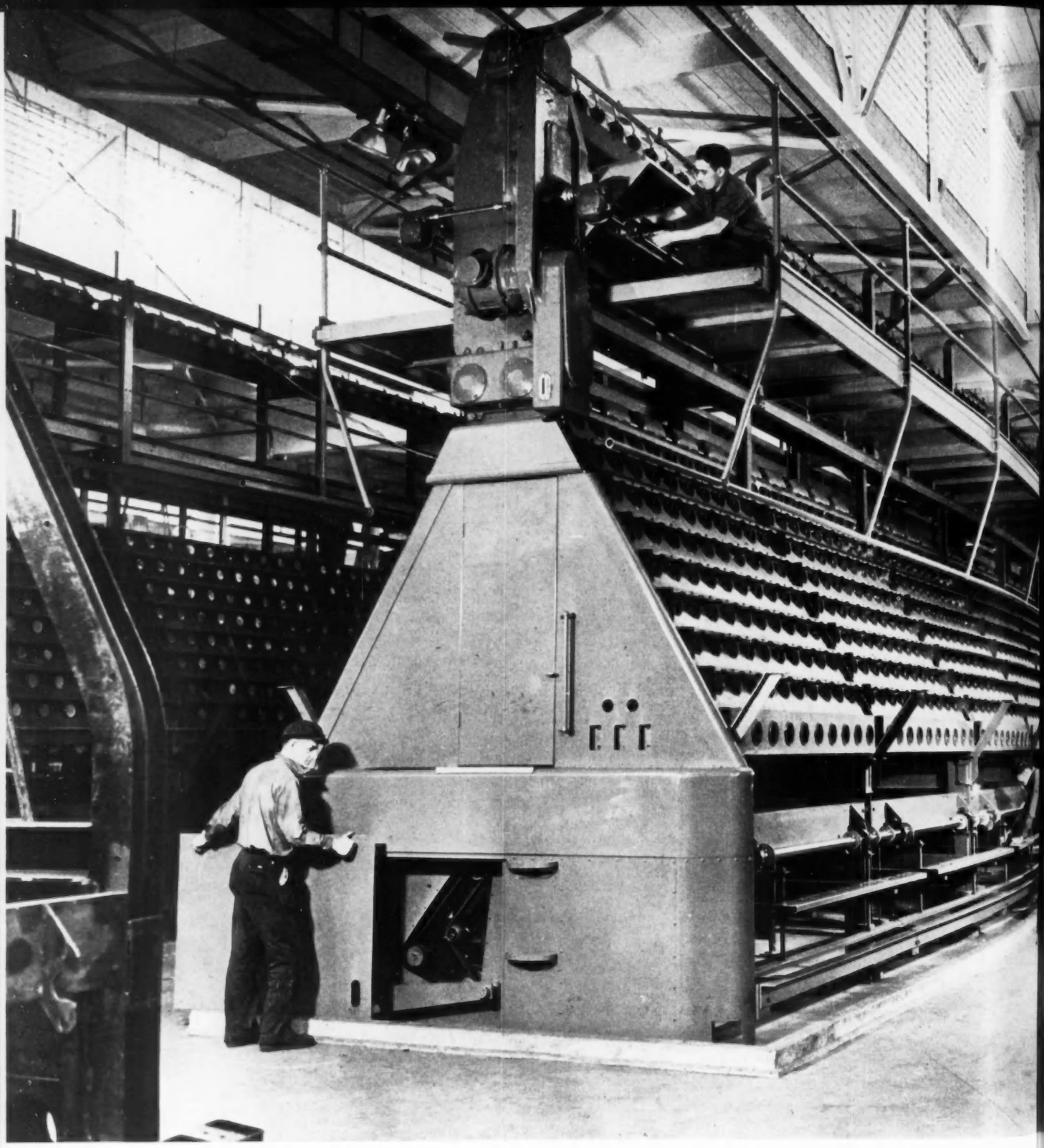
Thus reads in part Article I, Section 8, of the Constitution of the United States of America. And people being what they are, think almost entirely about the "exclusive Right" that is secured, thereby failing to recognize the power of the patent system. "To Promote the Progress of Science and Useful Arts." Ironically, in the adoption of the constitutional provision for a patent system the sole intent was to make available a vast fund of scientific knowledge by making it unnecessary for inventors to resort to secrecy for the protection of their discoveries. The granting of patent protection was looked upon merely as the means to an end; the monetary gain to the inventor was to be his reward for disclosing his discoveries; the royalties, paid in the last analysis by the public, were to be considered as the price paid for information that contributes to the public welfare.

Carrying out the intent of the Constitution, the Patent Office enables anyone who exerts himself to the extent of delving into the patent records to familiarize himself with the progress of the art and the details of discoveries and inventions. Smart and progressive companies and individuals do this and usually profit thereby. But there are too many who look upon the Patent Office merely as a bureau for granting patent protection. They are not smart.

There are many reasons why a systematic study of patents is valuable. An invention of 50 years ago may have had no commercial value at that time. The necessary materials out of which to make it might not have been available or the required production machinery might not have been in existence. Perhaps the invention was premature; a parachute in 1900 had no appreciable commercial value. As an another example, at that time the generally high cost of electricity greatly limited the field for domestic refrigerators. Often an invention was of little value only because a satisfactory marketing method was not applied or was not available. Innumerable "dead" patents that subsequently supplied the life blood for new enterprises or new lines of products can be cited. Leonardo da Vinci's inventions are classic examples of discoveries that, commercially speaking, were premature from every angle.

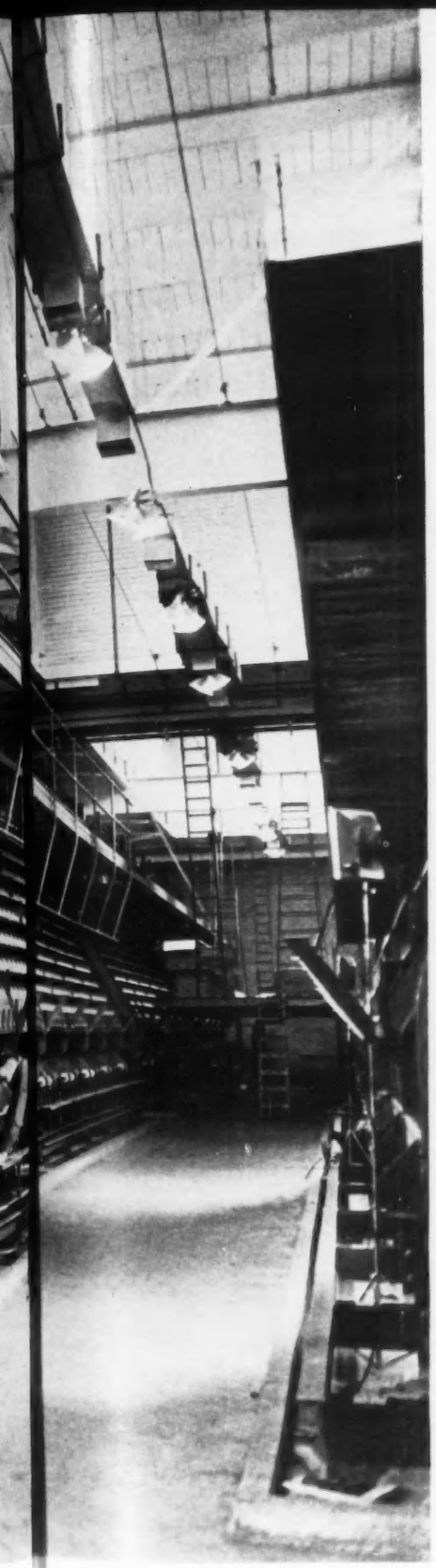
Undoubtedly the greatest source for new ideas is the Patent Office. Copies of all patents relating to an improved design that is to be developed should be procured and studied carefully. Use of the patent files to find out what has already been invented in a mechanism or machine that is to be improved usually brings to light unsuspected possibilities. Time and money are saved thereby and the final development will be far superior to what it would have been if the "prior art" had not been studied.

The Patent Office is yours. Think of it not only for "securing for limited Times . . . the exclusive Right to 'your' Discoveries," but look to it for knowledge with which "To Promote 'your' Progress 'in' Science and Useful Arts." To that end was the Patent Office dedicated.



ENGINEERING THE NEW

Cooperation of Designers and Equipment Suppliers Made the Machine Commercially Practical



RAYON MACHINE

Discussion of problems encountered in developing finished machine from pilot unit, emphasizing the ingenious design and cooperative industrial efforts behind it

CHARTING A NEW, untried path towards a visionary goal requires foresight, faith and unflagging zeal. Coupling these with sound engineering ability, Industrial Rayon Corporation and the Rayon Machinery Corporation have succeeded in creating and perfecting a radically new machine for extruding, processing and twisting synthetic textile yarns. Today, at Painesville, Ohio, their new plant, operating with 96 of these machines, is capable of producing 12,000,000 lb. of viscose rayon yarn per year.

The machine was designed in the face of apparently insurmountable difficulties and seeming impracticability made apparent by the failure of others in previous attempts at continuous spinning. By engineering resourcefulness and free exercise of selective processes in the mobilization of materials, equipment and services to perfect their machines, the engineers developed and built in 30 months one mile of these units, which require only a fraction of the motor horsepower necessary for conventional production of yarns.

As diagrammed in *P.E.*, March, 1939, page 98, usual production of viscose rayon yarn entails six to nine separate processing and batch handling operations, generally requiring approximately 90 hours. The new machines convert fluid viscose into finished rayon yarn in about six minutes in one compact continuous sequence in which the filaments making up each thread are carried forward over thread-advancing reels from the moment of extrusion until they have been completely processed, dried, twisted and wound on bobbins. All intermediate packaging and skeining is eliminated, the volume of material in process is greatly reduced, and a more efficient utilization of labor results.

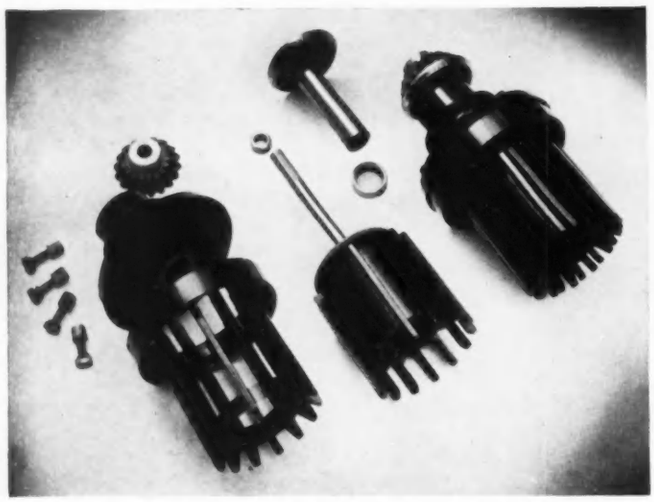
These accomplishments, plus the quality of yarn produced by the new process and equipment, are a tribute to the vision of the executives who allotted $2,000,000 for design research, and a credit to the engineering ability behind the development.

Initial development work was authorized in 1932, following discussions over a period of several years in which Hayden B. Kline, vice-president, convinced his associates at Industrial Rayon that a continuous process could be worked out, and that this was the only way in which direct treatment necessary for the efficient production of uniformly high quality rayon could be provided. When the principles of continuous processing, including the idea of an overhung thread-advancing reel, worked out by A. H. Burkholder, research chemist and Walter Knebusch, as research engineer, had evolved to a point which indicated their commercial practicability, the management turned to the outside for assistance in ironing out the mechanical kinks for commercial production of the machine. And this is where our story properly begins.

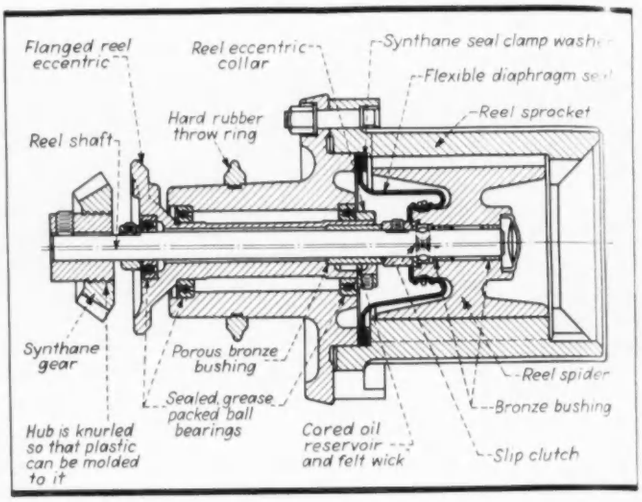
It begins with the formation of the Rayon Machinery Corporation in September, 1936 as a wholly-owned subsidiary of Industrial, under the management of George P. Torrence, formerly president, Link-Belt Company, and with Richard F. Bergmann, former assistant chief engineer of Link-Belt, as chief engineer in charge of design. To Mr. Bergmann was assigned the task of developing a machine incorporating the overhung thread-advancing reels to spin and process yarn at 9,600 individual positions simultaneously. Further, the machines were to be built and operating smoothly as soon as the plant could be completed.

Since plant construction was to be started at once, an immediate accurate estimate of final machine size had to be made. It was apparent at once that compactness and simple efficient grouping of drives could best be accomplished by building the machine cross-section in the form of a capital *A*. With the spin bath at the peak of the machine, yarn could be extruded from jets along each side of the tank and fed down two sides to the succession of processing reels on the stepped panels and then to bobbins at the base. Pumps and spinning and processing reels on two sides of the machine could be driven through a single panel, and another simple drive could serve the twister tables and spindles carrying the bobbins on both sides. Preliminary estimates of the machine size were within two inches of the final overall height, 19 ft. 6 in., and width estimates were correct within an inch of the final design, which is 11 ft. 4 in. wide.

The basic reel principle provided an overhung slat pulley and an interlocking cage of the same diameter, assembled to rotate together, but about different axes, and skewed in a manner which caused yarn to lead forward in a series of evenly spaced helical warps. The yarn spacing could be controlled to give any desired number of turns, from 9 to 70 per in. on standard yarns, depending on the degree of skew. The



Processing reel is overhung from the machine frame and is held in the welded cups by Allen cone-pointed screws



Processing reel, showing the overhung slat pulley and interlocking cage, which when rotated eccentrically produce thread lead

selection of the number of these would depend on the length of treatment required and the proximity necessary to allow the particular processing liquors or wash to bridge the gap between strands as the reels revolved. The reels were to be mounted in a slightly inclined position to enable liquids poured on at the outboard end to flow back over all the threads.

Processing Reel Problems

Commercial application of this idea, however, called for manufacture of each reel assembly with extreme accuracy, and as a unit which could be removed complete with its driving gear without interrupting production at other positions on the same 100-position machine.

A Durez compound developed by General Plastics had already been found to have the desired chemical and physical characteristics, and to be suited to accurate molding and manufacturing procedures, as well as to indefinitely long operation on the machine in the presence of warm corrosive liquids. The challenging molding problems were first worked out by the Richardson Company.

Each spinning and processing reel is made up of a slat or cage pulley, or reel sprocket molded of Durez, bored and bushed to mount on a ground steel shaft; a flanged reel eccentric of normalized grey iron, the flange and bearing bores machined concentrically, with the latter supporting the sprocket shaft. On the outside the casting is finished to provide an offset and skewed journal for an overhung Durez cage, the reel spider, fitted to a plastic flanged hub which rotates around the eccentric journal on sealed ball bearings; means for driving the sprocket shaft (either a tongue and mortice clutch or a plastic bevel gear).

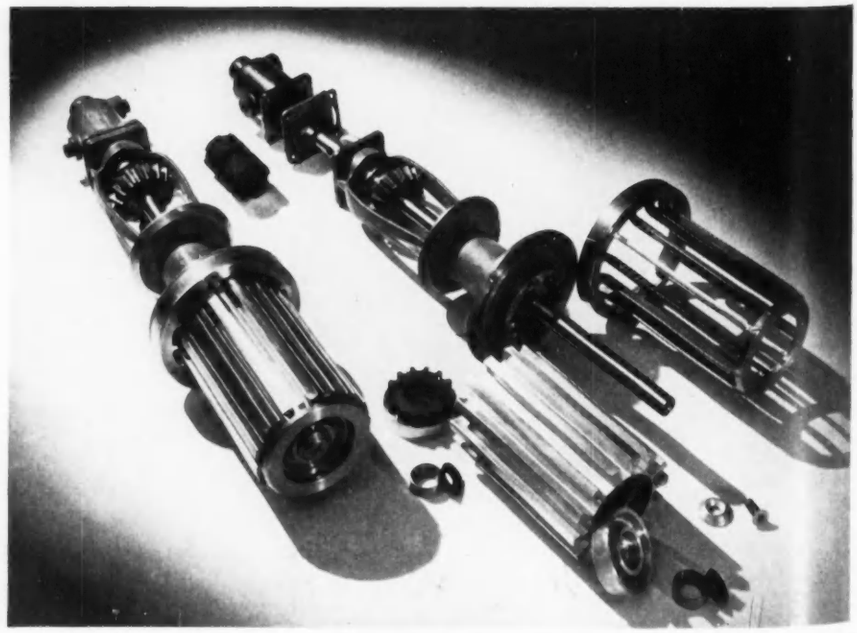
The bars of the sprocket alternate and engage with the bars of the spider, and the entire reel assembly thus revolves on the fixed flanged eccentric. Driving torque is applied through the shaft to the sprocket by means of an ingenious slip clutch in the sprocket hub.

A flexible diaphragm seal is clamped at its outer diameter between the spider and flanged hub, and at its inner diameter on the sprocket hub, to protect internal parts from the processing liquors. The sprocket hub is capped with a plastic plug at the front end.

Selection of bearings was based on the need for economical but durable and highly reliable elements, held to the smallest diameters possible. Early experiments were conducted with reels mounted on plain, grease-lubricated bearings. Operating studies quickly revealed the necessity for self-lubricating bearings which would maintain their accuracy indefinitely. Further, the outside journal bearing at the front end of the eccentric had to be positioned around, and eccentrically with respect to, the sprocket shaft bearing. Consequently, the sprocket shaft was mounted on an accurately sized porous bronze bushing at the front end of the eccentric, and on a shielded grease-packed ball bearing at the rear or bevel gear end. To provide a liberal reserve of lubricant for the bushing, an oil-soaked felt wick was inserted in a core in the grey iron eccentric.

Reel Clutch Design

The overload slip clutch typifies the ingenious engineering that is apparent throughout the machine. It was necessary to provide such a clutch to avoid undue



Extruded, cast and forged aluminum parts are used in the drying reel. Reel spider and sprocket, which serves as a water jacket, are mounted on shaft with recessed head screw

driving strains on the bars of the plastic reel members. In the first reels, torque was applied to the sprocket by a plastic shear pin through the shaft. If this was made weak enough to shear at the proper time with the reels in motion, it would be too weak to take the starting load. Furthermore, once the pin sheared, it was necessary to demount the entire reel assembly.

The solution, absurdly simple, lies in the use of a ball spring clutch. A hole cross-drilled through the shaft contains a coil spring between two steel balls which it forces into pockets drilled into a hexagonal steel insert. This is set in the plastic sprocket hub, where it is held in place by a snap ring. When the driving torque exceeds a predetermined maximum, the balls are forced out of their pockets against the spring pressure, into an annular race in the hex insert bore. Any individual reel can be stopped for inspection or service without clutching out an entire line.

Designing the Drying Reel

In order to dry yarn, a special heated reel had to be developed. Experiments were conducted with air-heated, electrically-heated and water-heated reels. Circulating hot water, heated by exhaust steam, offered the greatest opportunity for economical and uniform drying of the yarn, assuming that a practical and serviceable reel could be devised to utilize this drying medium.

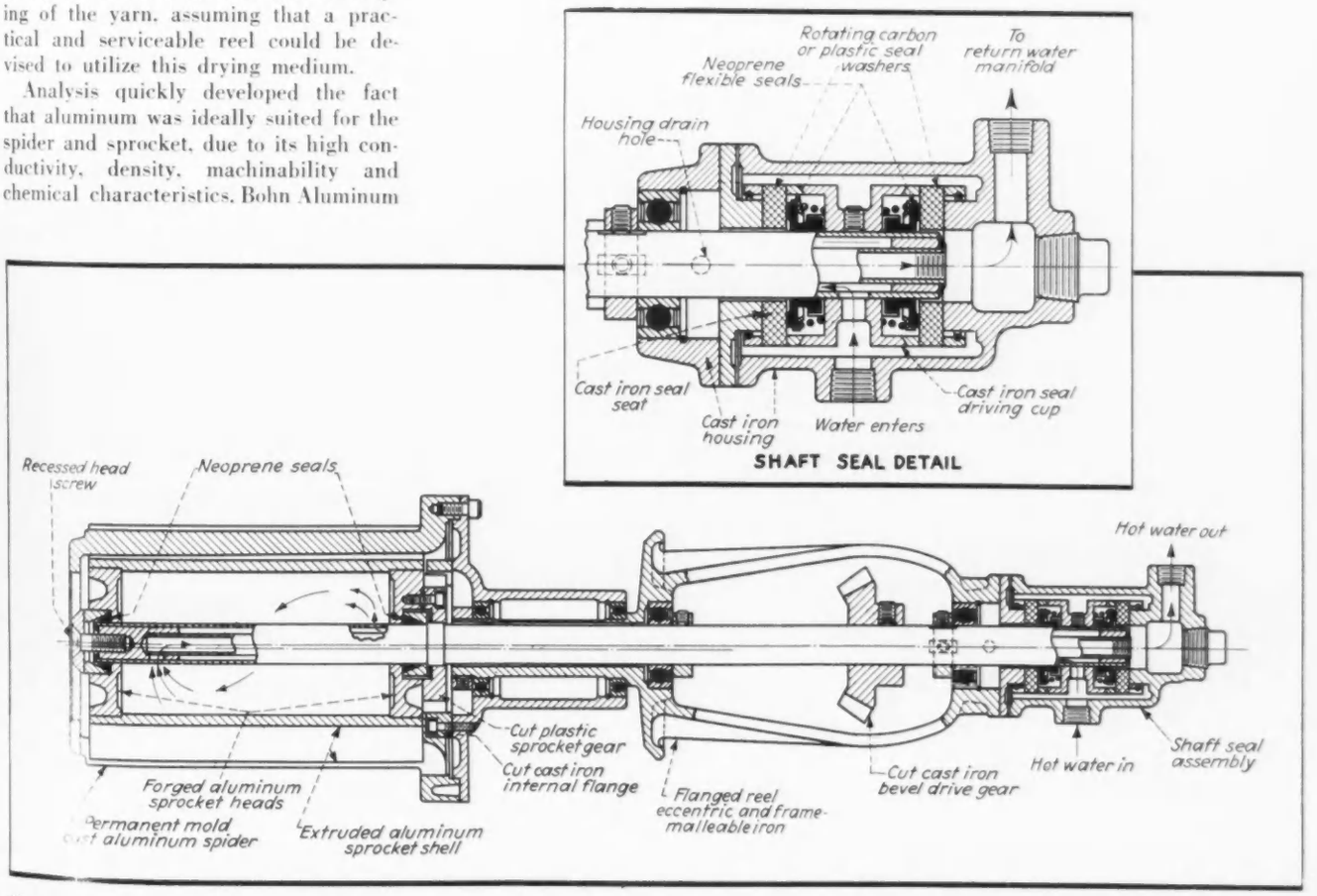
Analysis quickly developed the fact that aluminum was ideally suited for the spider and sprocket, due to its high conductivity, density, machinability and chemical characteristics. Bohn Aluminum & Brass Corporation furnished the blanks from which the finished aluminum reels were fabricated. These blanks consisted of fluted hollow extrusions of approximately 5 1/8 in. outer diameter for the sprocket, made of virgin 2S aluminum; forged heads of the same analysis, and 43S permanent mold castings for the spiders. The extruded blanks are counterbored at each end and finished forged heads are shrunk in place to form a permanently tight water jacket.

Since the spider must rotate with the sprocket, and bar contact between the aluminum members would produce wear, a cut plastic driving pinion on the back of the sprocket engages with a generated cast iron internal ring gear mounted on the spider flange.

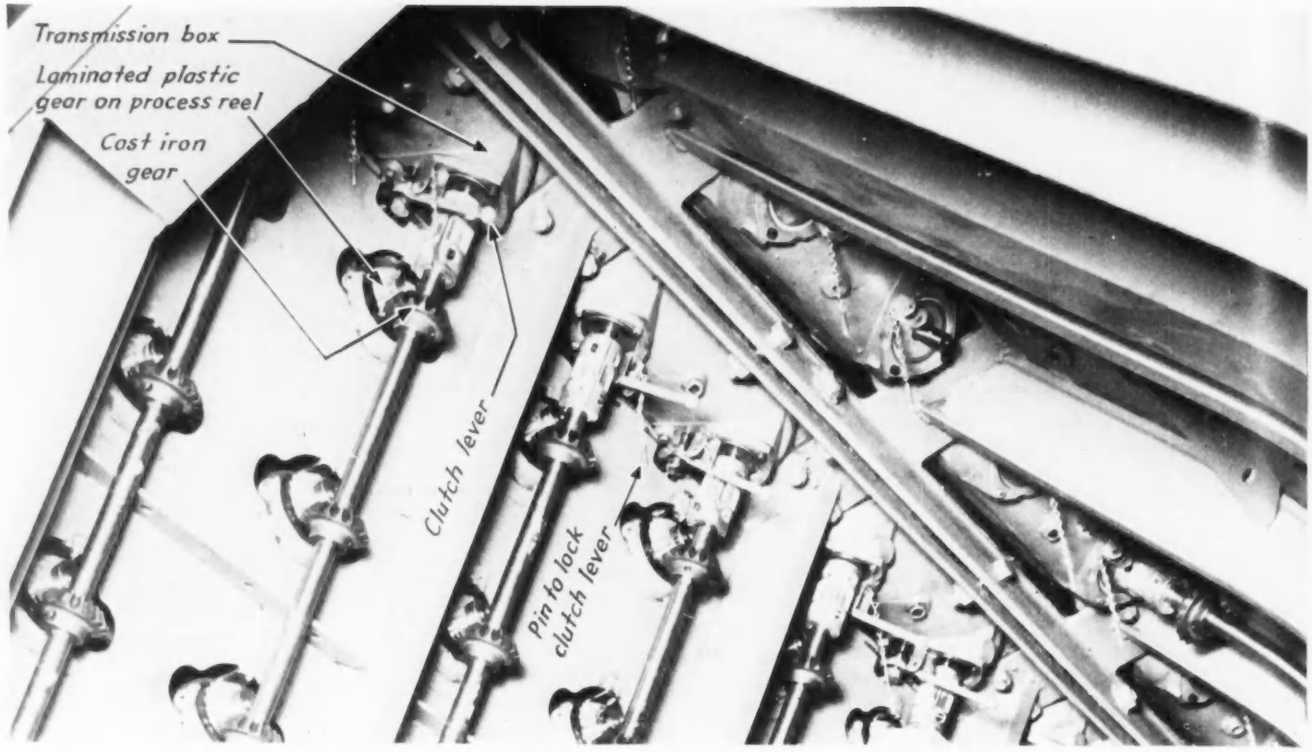
Hot water enters the outer jacket of a double tubular shaft, circulates through the hollow reel sprocket and flows out through the inner tube. How to seal off the shaft at the water connection was a problem. Stuffing box glands caused frictional losses and wore out the shaft. It was discovered that automobile manufacturers were at that time adopting a diaphragm-type water pump seal, which was tried and successfully adapted to this reel. These seals actually "lap in" in service, and absorb much less power than old-style stuffing glands.

Molded trays developed especially for this job by American Hard Rubber Company carry processing liquors which pour onto reels through bent glass tubes

The drying reel shaft is mounted on sealed grease-lubricated bearings. By mounting these bearings within the eccentric frame and cantilevering the sprocket and shaft assembly, it was



Hot-water reel assembly, illustrating water circulation through the double tubular driving shaft. Note the automotive-type water seal used at shaft end. Bevel driving gear is cast iron; it meshes with a Synthane gear on inclined driving shaft behind frame



Inclined shafts for driving process reels are supported at the lower end on ball bearings in forged housings. Shaft couplings to transmission box output shaft, shown at top, are die cast clamp type

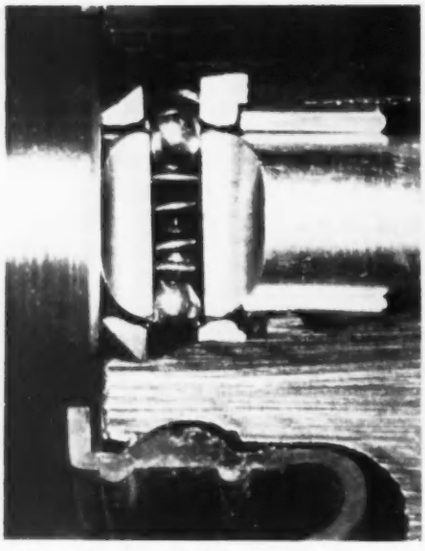
possible to use the same shielded grease-packed bearings for the spider as had been adopted for the plastic reels, at a great saving in cost. The drying reel sprocket is clamped with a Phillips recessed-head cap screw over the cone-shaped neoprene shaft seals. Hot water circulates through manifolds inside the machine *A*-frames under a head of 8 to 10 ft. from a heating tank on the top deck of the machine, equipped with steam coils and a Taylor temperature recording control.

Rayon Machinery Corporation will market reels of this type, not only for synthetic textile yarns but also for handling and treatment of wire, narrow band or film stock, and similar products. Reels may be flared to stretch the material or tapered to accommodate its shrinkage, and can be built in a wide range of diameters and lengths, and of many materials to suit the processing or handling problems encountered.

Drives and Lubrication

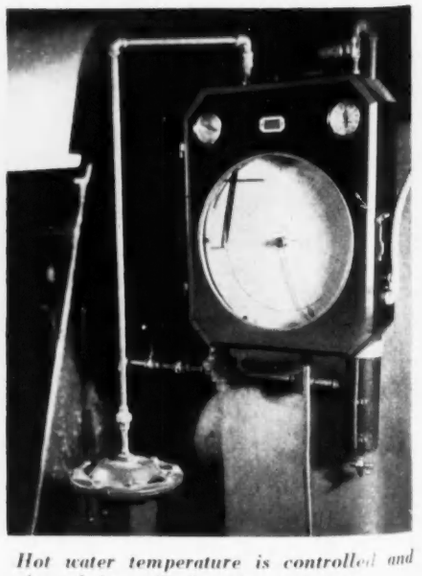
Motors at Painesville are flange mounted on oil-tight silent chain casings. Duplex silent chain drives with spring-backed automatic tension idlers transmit power to the several shafts or gear reduction units served by each motor. Positive lubrication of all silent chain drives is accomplished by gear pumps from an oil sump in each casing. Worm and spiral gear transmissions drive the 100 spinning and processing positions, each of which may be clutched out independently and locked for safety during servicing by the operator or mechanic. Spiral gear transmissions are equipped throughout with production automotive sizes of tapered roller and ball bearings.

Each process and drying reel is



Sectional view illustrating the ingenious slip clutch incorporated in the reels

Friction brake holds spindle stationary while bobbin is changed



Hot water temperature is controlled and charted by a Taylor instrument

driven from an inclined shaft on the back of the welded, stepped panel, through a pair of cut bevel gears, one of cast grey iron and the other of Synthane mascerated plastic molded on a steel hub. Lubrication of these bevels every six months has been found adequate. Shafts are ground, polished and straightened to close tolerances, and mounted in Fafnir sealed, grease lubricated ball bearings. Adjustable, flanged housings were used throughout, and doweled after alignment in erection.

As it passes from the drying reel, the finished yarn is "ballooned" over a stationary, twisting cap with a highly polished stainless steel skirt which introduces twists in the yarn as it is wound onto a light-weight Insurok plastic bobbin, which is rotated at high speed on a ball-bearing spindle.

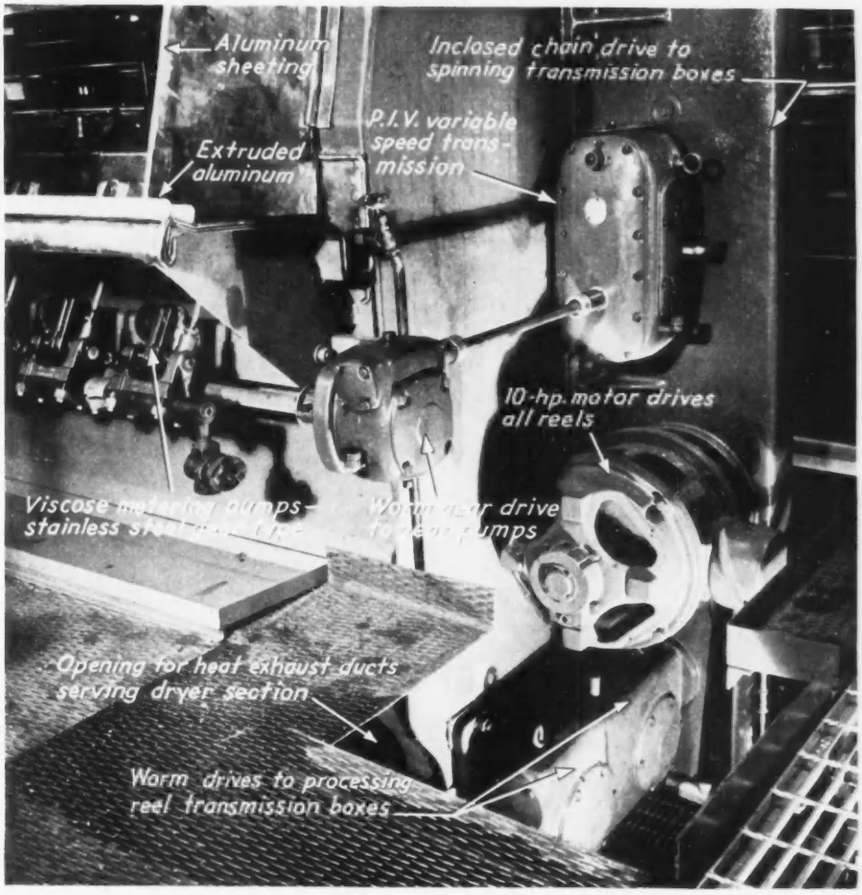
The 100 spindles for each machine are carried on a series of five light-weight welded steel tables or frames, which are counterweighted and are traversed vertically by means of a cam mechanism so as to lay the yarn evenly over the bobbins.

Welded Frame Most Economical

Despite skepticism throughout the industry as to feasibility of jig welding the frame and processing panels to the accurate tolerances demanded by the designers, this procedure was successfully employed at a tremendous saving in weight, cost and erection labor, with the assistance of Mr. A. F. McDonald and other engineers of the American Bridge Company. They cooperated in developing the frame design and the fabricating jigs and equipment for accurate checking of the finished work.

The drive-end *A*-frames and intermediate frames are made up of bent column sections milled on the bottom ends and flame-cut to fit at the top. The machinery boxes for the drive-end *A*-frames are made up of commercial plates, bars and rounds assembled in the jig and welded, and then machined and welded to the *A*-frame. The cups in which the flanged process and drying reel mounts are fitted were stamped and counterbored, prior to jig welding into the sloping panels of which they are a part. Accurate alignment of these cups were necessary for proper operation of the bevel gears which drive the reels from the inclined shafts.

It is just 26 months since the Rayon Machinery Corporation emerged from its loft and set up shop for the light manufacturing, storage and assembly of parts for a pilot machine applying the contemplated design. Today that $11,500,000 development, completely equipped and in operation, demonstrates what can be accomplished by "open-minded" design.


Aluminum sheeting
Inclosed chain drive to spinning transmission boxes
P.I.V. variable speed transmission
Extruded aluminum
10-hp. motor drives all reels
Opening for heat exhaust ducts serving dryer section
Worm drives to processing reel transmission boxes

CAST IRON DESIGN

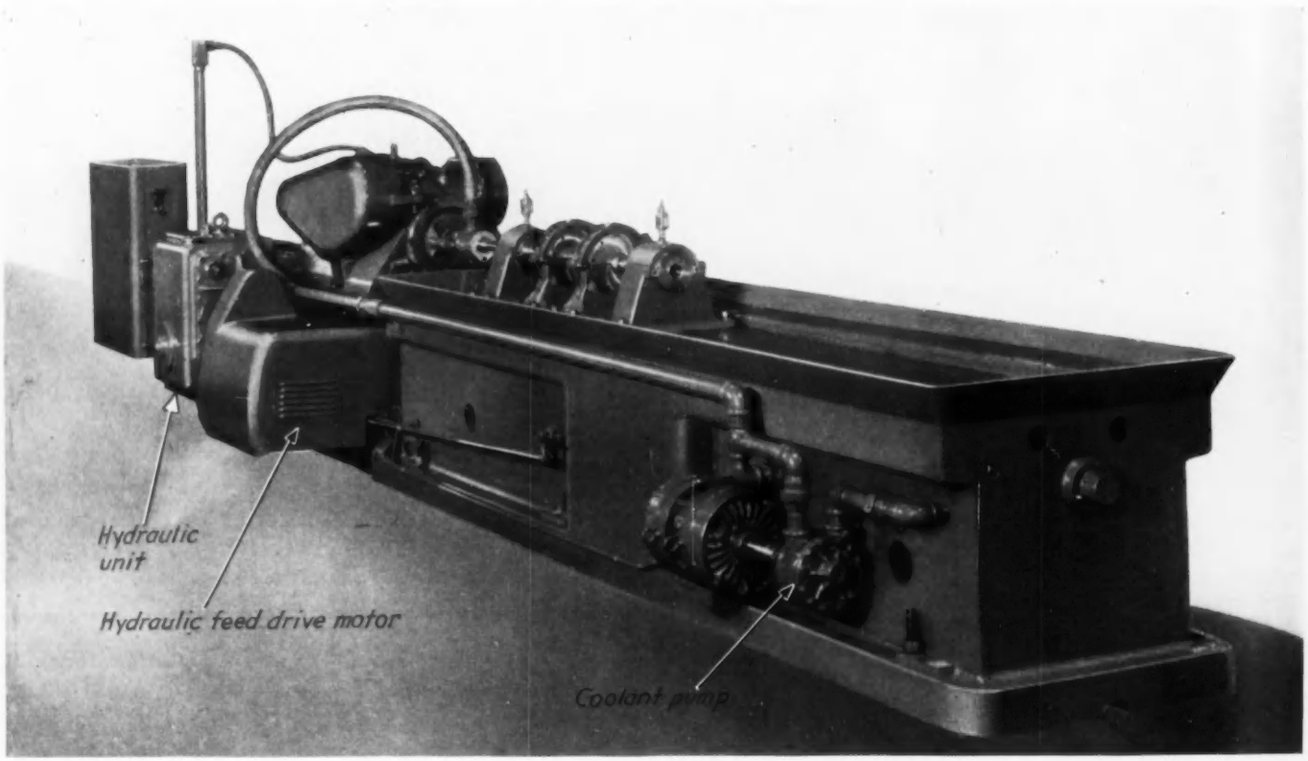
DESCRIPTION	REQ'D FOR ONE ASSEMBLY			REQ'D FOR ONE MACHINE	
	NUMBER OF PARTS	WEIGHT EACH	WEIGHT PER ASS'Y	NUMBER OF ASSYS	WEIGHT
"A" FRAME	1	660	660		
SAMSONS	2	440	880		
CYLINDER FRAME	1	320	320		
INT. FRAME ASSEMBLY	TOTAL WT. 1,860			5	9,300 Lb.
"A" FRAME	1	660	660		
SAMSON	1	440	440		
CYLINDER FRAME	1	240	240		
DRIVE SAMSON	1	900	900		
DRIVE END FRAME ASSEMBLY	TOTAL WT. 2,240			1	2,240 Lb.
PANEL BRKTS	2	130	260		
SAMSONS	2	400	800		
CYLINDER FRAME	1	240	240		
INT. FRAME ASSEMBLY "F"	TOTAL WT. 1,300			5	6,500 Lb.
INT. SPIN FRAMES	1	260	260	5	1,300 Lb.
DRIVE END SPIN FRAMES	1	600	600	1	600 Lb.
PROCESS PANELS	1 1	400 2000	3,400	10	34,000 Lb.
TRAVERSE LIFTER BEAM	1	145	145	10	1,450 Lb.
SPINDLE RAIL BRACKETS	1	25	25	12	300 Lb.
PROCESS DECK BRACKETS	1	115	115	12	1,380 Lb.
SPIN HOOD BRACKETS	1	10	10	10	100 Lb.
SPIN APRON BRACKETS	1	30	30	12	360 Lb.
TOTAL WEIGHT CAST IRON PARTS PER MACHINE					57,530 Lb.

WELDED STEEL DESIGN

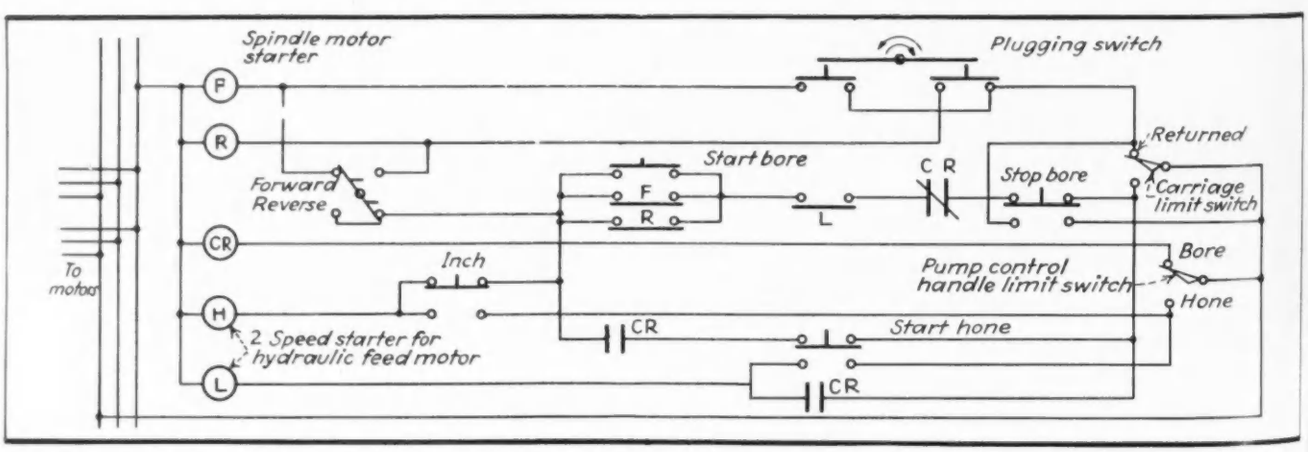
DESCRIPTION	REQ'D. FOR ONE MACHINE		
	NUMBER OF PARTS	WEIGHT EACH	TOTAL
INT. FRAMES	5	1,000	5,000 Lb.
DRIVE END FRAMES	1	1,450	1,450 Lb.
CYLINDER BEARING SUPPORTS	5	170	850 Lb.
ROCKER SHAFT BEAR. SUPPORTS	10	185	850 Lb.
INT. SPIN FRAMES	5	180	900 Lb.
DRIVE END SPIN FRAMES	1	400	400 Lb.
PROCESS PANELS	10	1,130	11,300 Lb.
TRAVERSE LIFTER BEAM	10	70	700 Lb.
SPINDLE RAIL BRACKETS	12	16½	200 Lb.
PROCESS DECK BRACKETS	12	25	300 Lb.
SPIN HOOD BRACKETS	10	5	50 Lb.
SPIN APRON BRACKETS	12	8½	100 Lb.
TOTAL WEIGHT WELDED STEEL PARTS			23,100 Lb.

Modern Designs

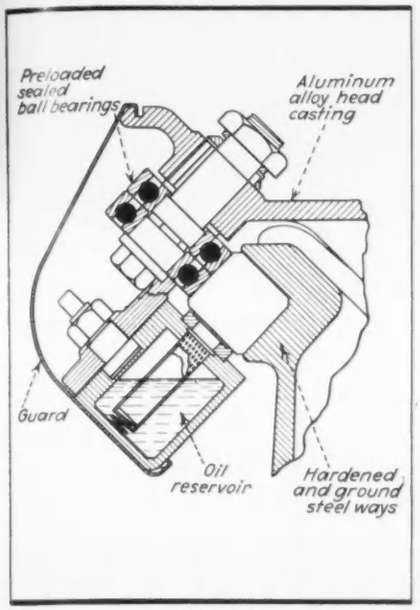
Dual Control for Boring and Honing in Hydraulic Machine



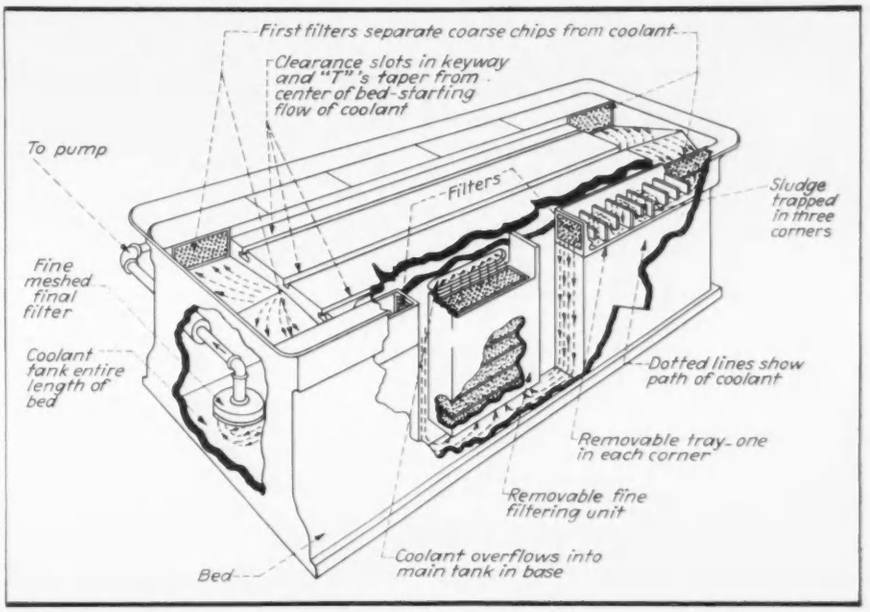
Interlocked electric and hydraulic circuits are designed into this W. F. and John Barnes machine. The machine is adapted to boring or honing in a wide range of diameters and lengths. Honing cycles can be manually or automatically controlled. Adjustable, positive-trip stops for blind end boring and for boring long cylinders permit operator to leave machine unattended without damaging work. Base of machine is cast in two sections; coolant is stored in the left hand side, the main casting under the machine head supports all operating parts. Honing feeds are adjustable between 35–60 ft. per min.; boring feeds may be varied from 0.062–12 in. per min. by hydraulic valve.



Electric control circuit showing only parts essential to machine operation, omitting for purposes of clarity the usual standard safety features. Dual control is provided for boring or honing; no complicated changeovers are necessary. Adjustment of traverse-pump delivery determines speed of hydraulic motor, which is mounted on the rear of the machine. Flexibility is increased by providing for spindle operation in either direction for boring and honing. Quick stop of spindle regardless of direction of movement is accomplished by electrical plugging.



Way-surface friction and also inertia must be held to a minimum at the high reciprocating speeds, hence head casting is of lightweight aluminum alloy and is supported on ball bearings, eccentrically mounted to permit easier alignment.

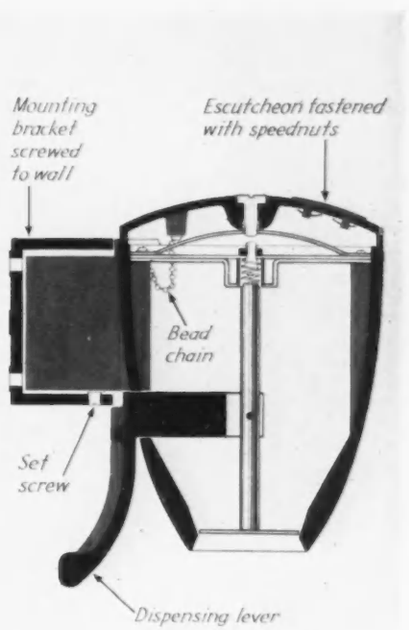

First filters separate coarse chips from coolant
Clearance slots in keyway and "T"'s taper from center of bed starting flow of coolant
To pump
Filters
Sludge trapped in three corners
Fine meshed final filter
Coolant tank entire length of bed
Dotted lines show path of coolant
Removable tray one in each corner
Removable fine filtering unit
Bed
Coolant overflows into main tank in base

Chips and grit are removed from coolant by filtration system shown schematically above. Coolant for boring is supplied to the tool through the center of the boring bar. Coolant for honing is delivered to the end of the cylinder farthest from machine head. Control of coolant is independent of machine control; flow is started and stopped by separate push button. Dotted line shows path of coolant through filters and sludge trap to fine filtering unit.

Plastics Simplify Assembly, Improve Appearance

Soap dispensers must withstand exposure to water and steam and attendant corrosion and scaling. To attain good resistance at a reasonable cost without resorting to expensive metals or heavy finish coatings, Barnes and Reinecke designed the new Pax soap dispenser with molded plastic parts.

First steps in adapting basic idea to plastic design, showing the manufacturer's rough model of metal and the preliminary plastic model. The design is made up of five major parts, all molded of Textolite: bowl, cover, lever, and the mounting bracket which conceals mounting screws.

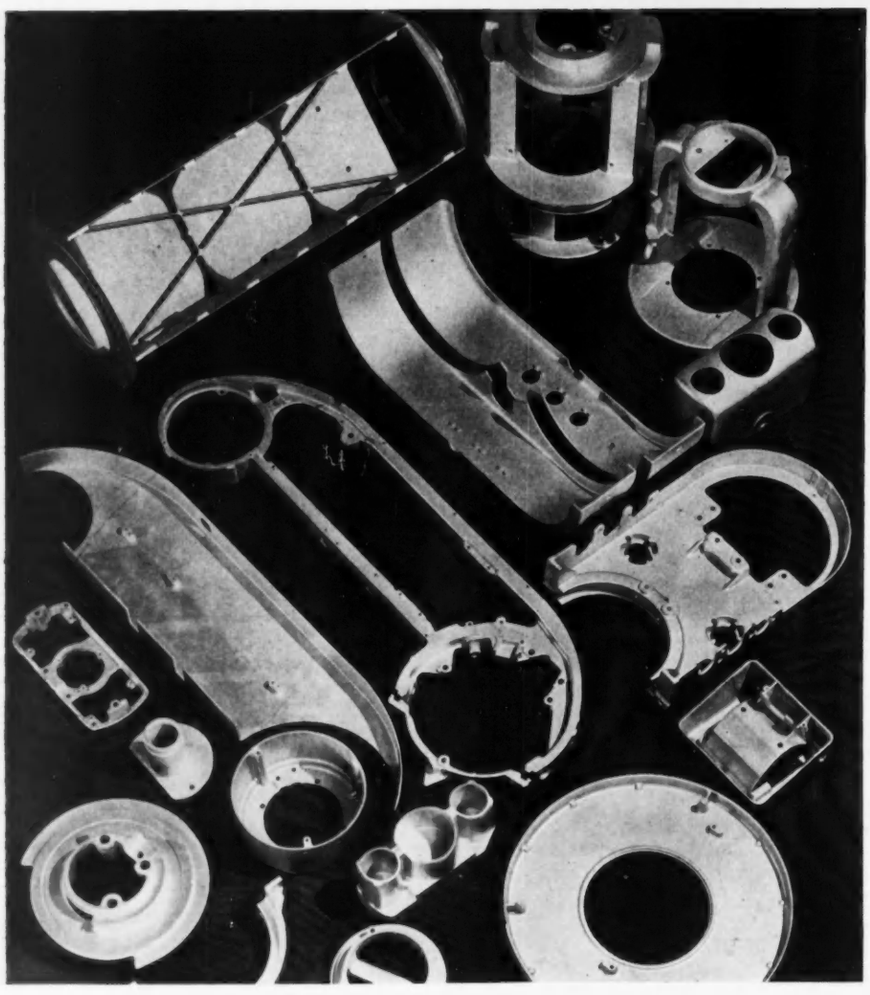


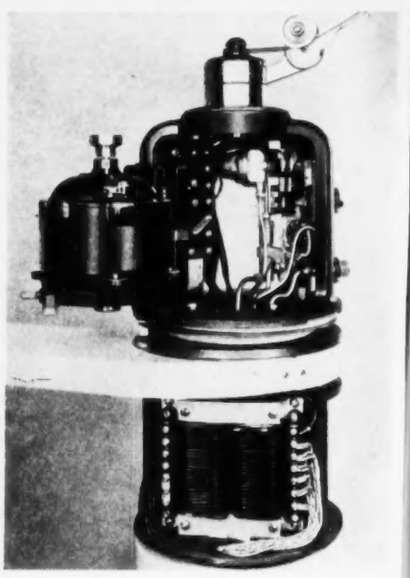
Section through dispenser shows method of attaching cover by short key-top bolt held in cover by expanding ring, method of attaching nameplate with speed-nuts snapped over lugs molded in. Cover cannot be dropped; it is anchored by bead chain. Dispenser shank is held in bracket by set screw.

Modern Designs —Major Structural Parts Die-Cast Aluminum

Weight and machining costs reduced in compact dental unit redesigned to eliminate unsightly appendages, increase operating convenience

DEMONSTRATING the practicability of applying streamlined, lightweight construction to dental equiment, the new S.S. White Master unit main pedestal frame, motor support frame, arm frames, base plates and heater housings are die-cast aluminum. Use of die-casting permitted production of these parts to close dimension, with little machining necessary before assembly. Aluminum provided the necessary strength and durability. The radically new design has no superfluous adornment, unsightly piping and dirt catching crevices, and centralizes utilities to minimize amount of movement required of the operator. Pedestal covers are finished in baked enamel; base cover and retaining bands on the pedestal are stainless steel. Motor, wiring and piping are concealed within pedestal they are accessible by removing retaining bands and covers.

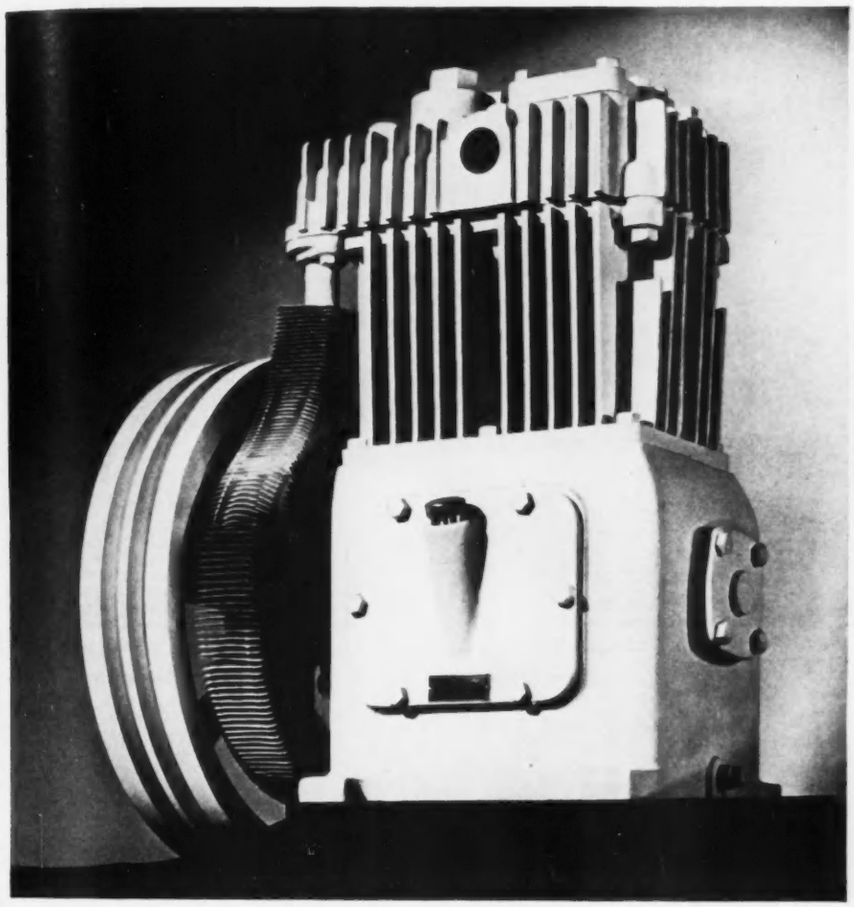


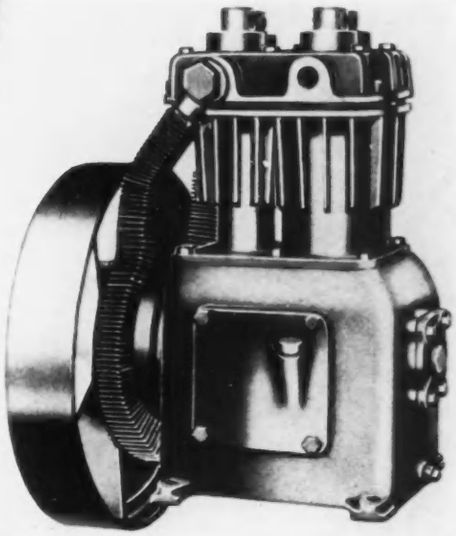


Motor is mounted on rubber shock absorbers, and has a flexible universal joint connection to pulley shaft. It is supported in a swinging cradle, can be removed entirely for servicing. Pulley shaft runs in self-lubricating bearing.

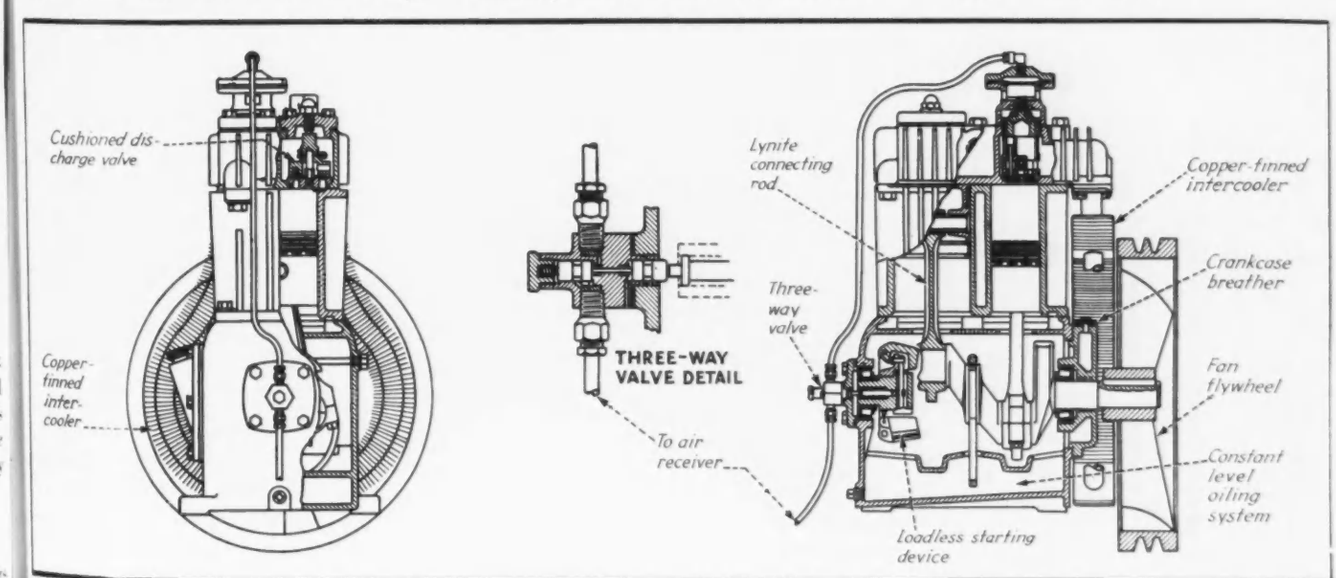
Seventeen aluminum die-castings which comprise the major structural parts of the unit reduced machining and assembling costs without sacrificing strength, or durability. Unit is considerably lighter than conventional models.

Streamlined Compressor Incorporates Loadless Starting Device



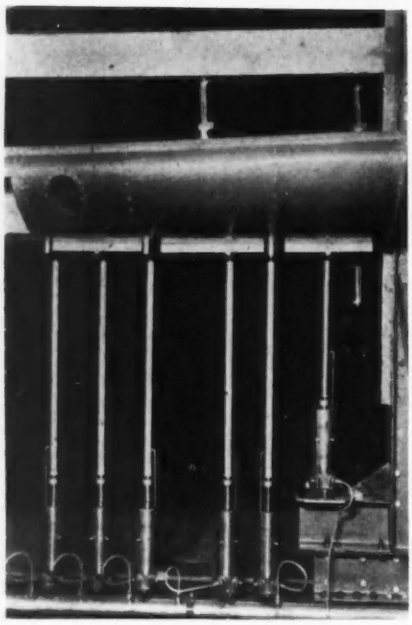


New Quincy compressors, in nine models ranging in size from 2.8 to 30.1 cu. ft. per min. piston displacement, have been designed for better appearance as well as better mechanical efficiency. Previous models, such as above right, were entirely functional in design. In the new model, deep vertical fins on the cylinders, beside increasing radiation area 12 percent, contribute to the streamlined styling of the unit. Construction was simplified, and cushioned alloy steel valves and a constant level oiling system were incorporated in the design. Overall efficiency has been increased 7 to 10 percent through cooler operation and reduction in friction load. H. Wood Miller, industrial designer, created the new exterior working in cooperation with George Pfeifer, head of the Quincy engineering department, who was in charge of all mechanical improvements. When furnished for stop-start automatic operation, compressors are equipped with a loadless starting device.

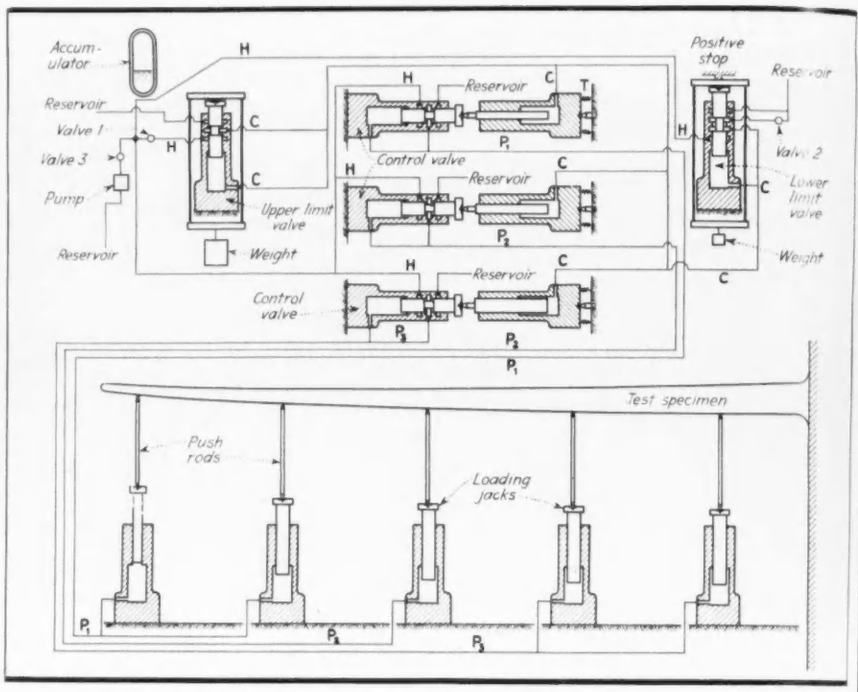


Design features include cooling by combination fan-flywheel; Lynite connecting rods whose high strength-weight ratio helps reduce inertia and vibration; and constant level splash-type lubrication. Oil spray from connecting rod caps lubricates cylinder walls and main bearings. Loadless starting device, which utilizes a fly-ball governor actuating a three-way valve, assures unloading of compressor when machine idles. On stopping, fly weights fall, admit tank air which lifts intake valve and vents cylinder. Upon starting, weights close three-way valve, permitting normal operation.

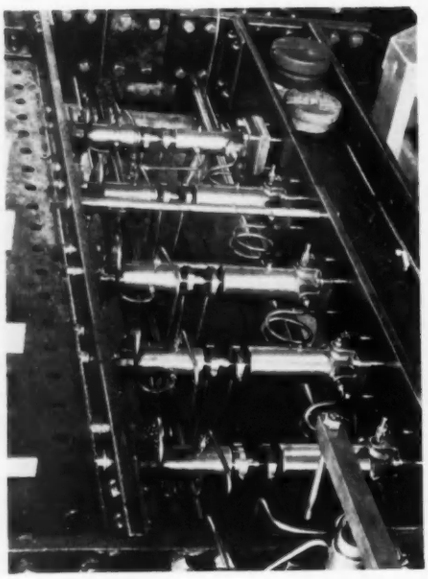
Modern Designs—Testing Machine Has Load Maintaining Valves



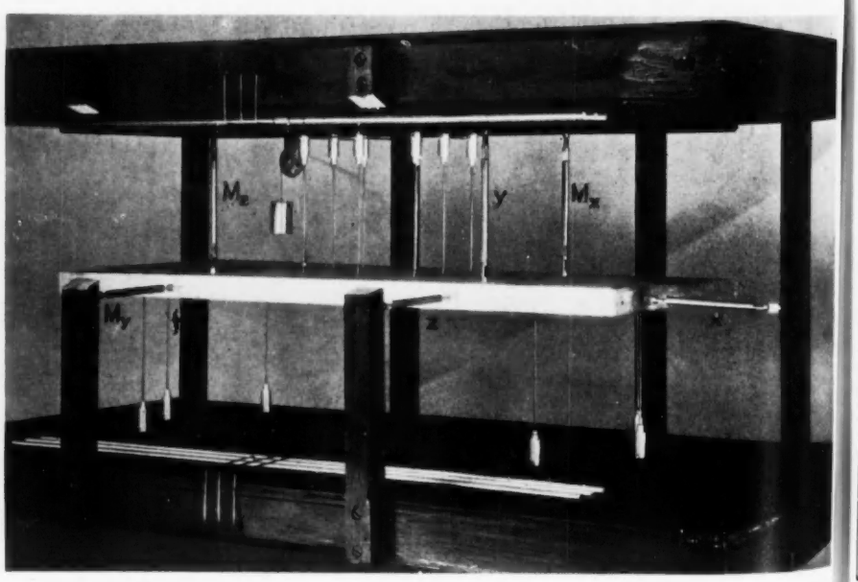
Airplane wing of special design being tested under loading produced by hydraulic jacks, with compressive force transmitted through steel push rods pointed at each end so as not to transmit shear, bending or torsion. Jacks are lapped and have no packing. Load may be maintained, or increased or decreased by any desired percentage steps, and there is a minimum of obstruction to the application of measuring instruments. Machine, incorporating load maintaining valves, was developed by Professor George E. Beggs.



Testing circuit, showing how the hydraulic jacks are actuated by precisely controlled pressures. Pressure control is centered in the upper and lower limit valves and the control valves. The plungers of the limit valves have a single groove sufficiently wide to span any two of the three adjacent circumferential smaller grooves in the cylinder wall. With valve 3 and valve 2 closed, valve 1 open, and the pressure *C* at its proper value, the position of the upper limit valve plunger will be as shown with the upward force exactly balanced by the weight. Should pressure decrease for any reason, an unbalance would exist, the plunger move down and high pressure admitted to correct the condition. Conversely, should pressure increase, the plunger would move up, the oil would drain and pressure would be decreased. Control valves operate similarly; constant force against valve plunger is provided by the same pressure *C*.

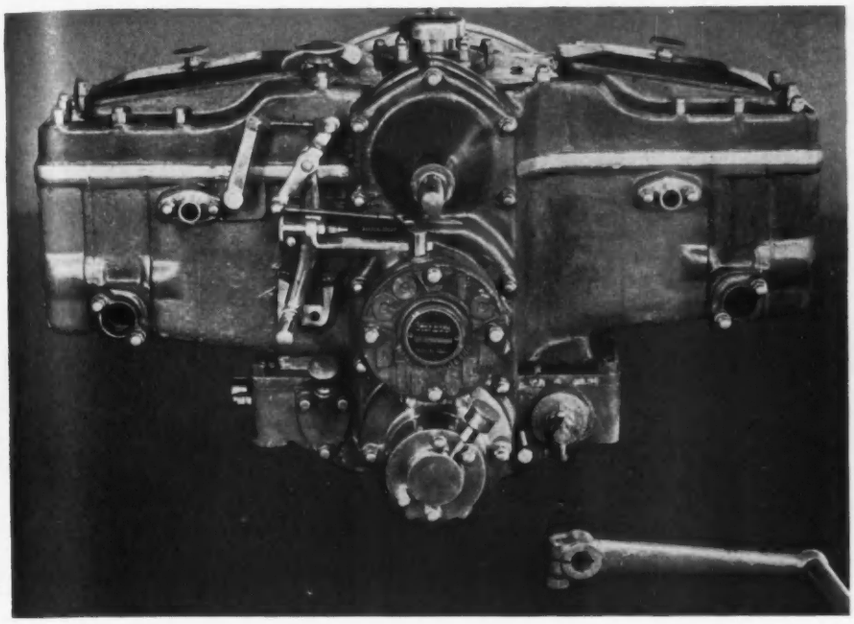


Control jacks, operating against control valves, are mounted in a horizontal plane so that weight will not act in direction of valve axes. To minimize friction caused by plunger weight on cylinder walls, plungers are oscillated.

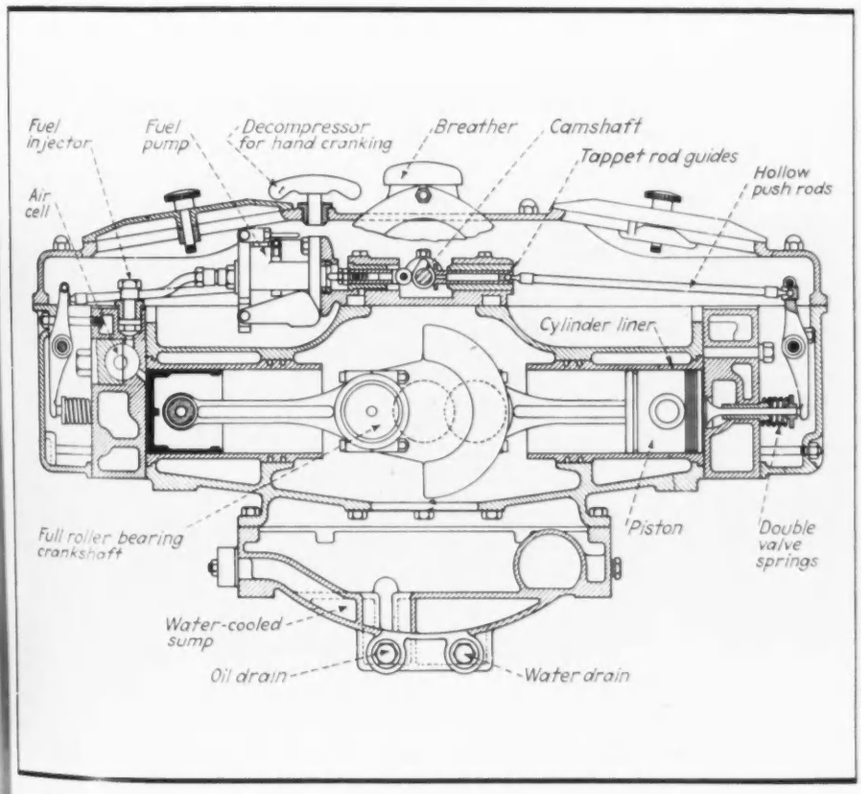


Floating structure testing set-up. Rigid body translation in three directions and rotation in three senses must be prevented while elastic deformations remain unrestricted. Three stabilizing rods, *X*, *Y* and *Z*, attached to the frame of the testing machine, connect at a point within the model and prevent translation. Three other rods, M_x, M_y and M_z in the *YZ*, *XZ* and *XY* planes, perpendicular to the axes of the *Z* or rods, prevent rotation.

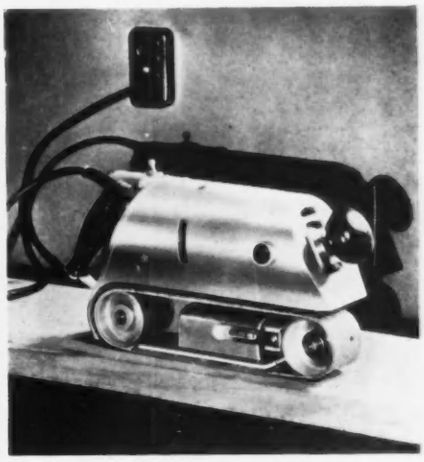
Modern Designs



Weighing only 280 lb., including a 60-lb. flywheel, this 15–18 hp. Covic diesel has approximately the same weight-power ratio as conventional gasoline-powered truck engines. The small size and low weight, resulting from patented design and utilization of high-strength alloy steels for engine parts, makes possible application of diesel power where space is at a premium. This engine is distributed in this country by the Northill Company. Installations include contractor's equipment, industrial tractors, portable compressors.



Metal alloys, used extensively throughout the engine, reduce weight without decreasing strength. Crankcase is a rigid nickel-iron casting; the built-up crankshaft has center section of nickel-chrome steel and end sections of nickel-chrome-moly steel; piston rods are forged from heat-treated high-tensile steel. Aluminum alloy cover plates, easily removed, house the fuel pumps, injectors and valves. Water-jacketed gear pump furnishes pressure lubrication.



Die-cast aluminum frame, finished in baked aluminum enamel, helped reduce total weight to nine lb. in the Syracuse Guild Tool Sander. Compactly designed tool is driven by a universal motor at 600 ft. per min. belt speed.

RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

The new Unitype Hunter Electro-Copyist contains complete equipment for photo-copying letters or drawings up to 14 x 19 in. in size. Inbuilt drainage connections are provided for the developing and fixing trays.

* * *

A new light-weight anchor, fabricated from monel sheet, is welded throughout, except where the arms and stock meet the shank. Joints are pinned so that the anchor can be folded for storing when not in use. The anchor is made in a variety of sizes, 6 lb. to 48 lb. in weight, and it is so designed that the 11 lb. size will hold a boat 38 ft. in length.

* * *

The weatherstrip at the bottom of Kinnear motor-operated rolling doors actuates an automatic switch by pneumatic action the moment an obstruction is bumped. Switch stops and reverses the door instantly.

* * *

A gasoline blow-torch is the heating element in the new Turner metal spray gun for lead-tin alloys. It is claimed to melt standard rods or bars of solder and spray them at comparatively low air pressures. Applications range from automotive body work to the preparation of non-metallic objects for electro-plating.

* * *

To eliminate friction and consequent scratching between film layers, Bell & Howell Company mounts the reel of its new B & H 800 ft. continuous projector attachment in a horizontal plane.

GLASS FABRIC INSULATION

For Electrical Machinery and Control Apparatus

GRAHAM LEE MOSES
Westinghouse Electric and Manufacturing Company

New electrical insulating materials made of fibrous glass that resist the high temperatures encountered in electrical machinery, that improve space factors and that do not absorb moisture

GLASS because of its excellent insulating characteristics has long been used by the electrical industry. Since the development of fibrous glass, however, a vast new field has opened for its use as electrical insulation.

Much development and research work has been done to make possible low-cost production of minute glass fibers of uniform size and quality in large quantities. The diameter of the individual fibers is closely controlled in manufacturing and ranges from 0.0002 to 0.0003 in. Two basically different processes have been developed for the production of glass fibers.

First to be developed was the "staple fiber" process which consists of flowing molten glass through small holes in a platinum bushing in combination with steam pressure. The fibers fly out in short lengths from 4 to 12 in. long, these are picked up on a revolving drum. Later the fibers are spun into yarn and woven into cloth by processes similar to those used by the cotton industry.

The "continuous filament" process was a subsequent development. It consists of drawing the molten glass through fine holes in a platinum bushing. The filaments are wound on rapidly revolving spindles which draw out the molten glass, thereby reducing the size of the filament. In this process the speed of drawing the finished filament controls the diameter. Yarn is spun and woven by processes similar to those used in the silk and rayon industry.

In both processes electrically heated crucibles are used to melt the glass. Glass in the form of "marbles" is fed into the crucibles in carefully metered quantities to maintain the molten mass at a constant level. A single "marble" three-quarters of an inch in diameter can be spun into an almost invisible filament approximately 70 miles long.

Ordinary soda glass has an affinity for water. Therefore, it was found necessary to develop a new formula for the glass used in insulating fabrics. This is an "alkali-free" glass which is not only resistant to moisture but has better electrical characteristics, in that, the insulation resistivity is much higher and is less affected by temperature changes.

Glass textiles have many desirable characteristics which can be summarized as:—

1. Resistance to deterioration at high temperatures
2. Non-inflammable
3. Great tensile strength
4. High insulation resistance
5. Non-hygroscopic
6. Excellent di-electric breakdown strength when impregnated
7. Resists attack by moisture, acids, oils, and corrosive vapors
8. Good thermal conductivity
9. Excellent appearance when treated.

Glass insulating materials are available in several forms:

TAPE, in any standard thickness or width. The present limit on minimum thickness is 0.003 in. for continuous-filament tape and 0.010 in. for staple-fiber tape.

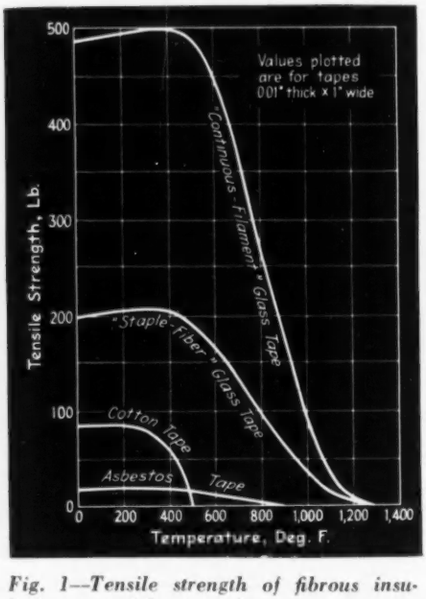


Fig. 1—Tensile strength of fibrous insulating materials at various temperatures

BRAIDED SLEEVING. This is made from continuous-filament yarns in many standard inside diameters.

GLASS-INSULATED WIRE. All sizes of round wire are being covered successfully with glass yarn, and many sizes of square and rectangular wire have been covered. Various thicknesses of wall are being used, depending upon the application, to produce an insulated wire size corresponding to standard asbestos-covered, cotton-covered, enamel and paper-covered, and silk-covered sizes.

CABLE is also being insulated with glass yarn or tape for high temperature duty.

WOVEN CLOTH. This is available at present in thicknesses of 0.002 in. and larger.

COMBINATION GLASS AND MICA. Combination slot cells of glass cloth (or mat) and mica splittings are being developed which may result in a higher class B insulation for this application.

This new insulating material has been also used for insulating electrical apparatus, such as

- Field Coils, with
  - Glass covered wire
  - Tape for finishing
- Armature Coils, with
  - Conductor insulation
  - Binding tape
  - Finishing tape
  - For "spot taping" leads and loops
  - Sleeving on leads
- Magnet Coils,
  - Glass covered magnet wire
  - Sleeving on leads
  - Wrapper under terminals
  - Finishing tape

Glass fabrics have a high tensile strength as compared with other textiles. This desirable characteristic permits the use of thinner tapes and wire covering in many applications. Improved "space factor" results in important design advantages. Because glass textiles do not contain any organic materials their tensile strength is affected little up to temperatures of 300 deg. C. (572 deg. F.). They are 100 per cent inorganic and do not deteriorate in mechanical or electrical characteristics at temperatures far above those now permissible in electrical machinery. When wrapped around a tube, glass tape takes a permanent set at 732 deg. C. Its "strain point" is 807 deg. C. and "softening

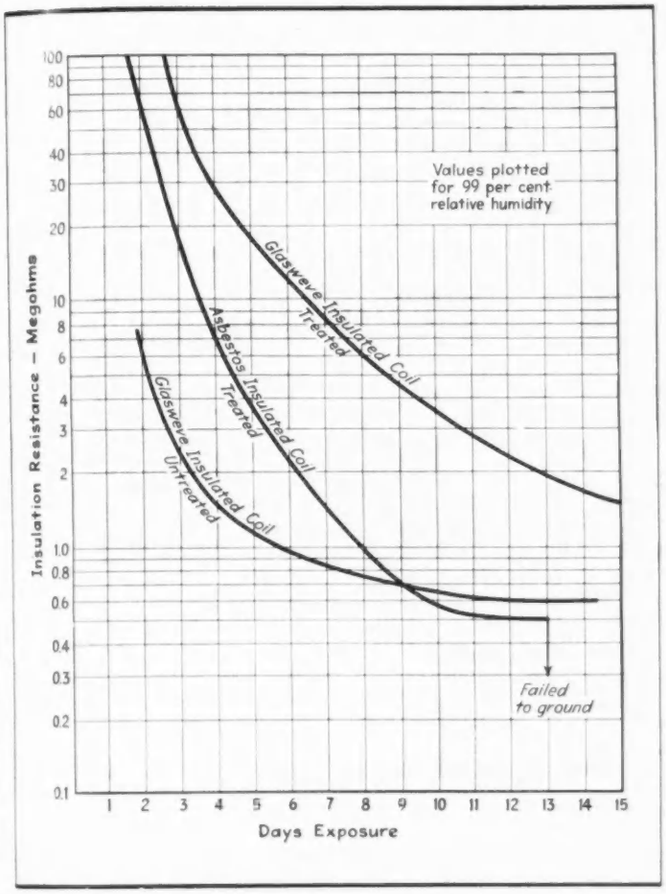

Values plotted for 99 per cent relative humidity
Glaswevе Insulated Coil Treated
Asbestos Insulated Coil Treated
Glaswevе Insulated Coil Untreated
Failed to ground
Insulation Resistance — Megohms
Days Exposure

Fig. 2—Effect of humidity on coils impregnated with solventless varnish as compared to no treatment

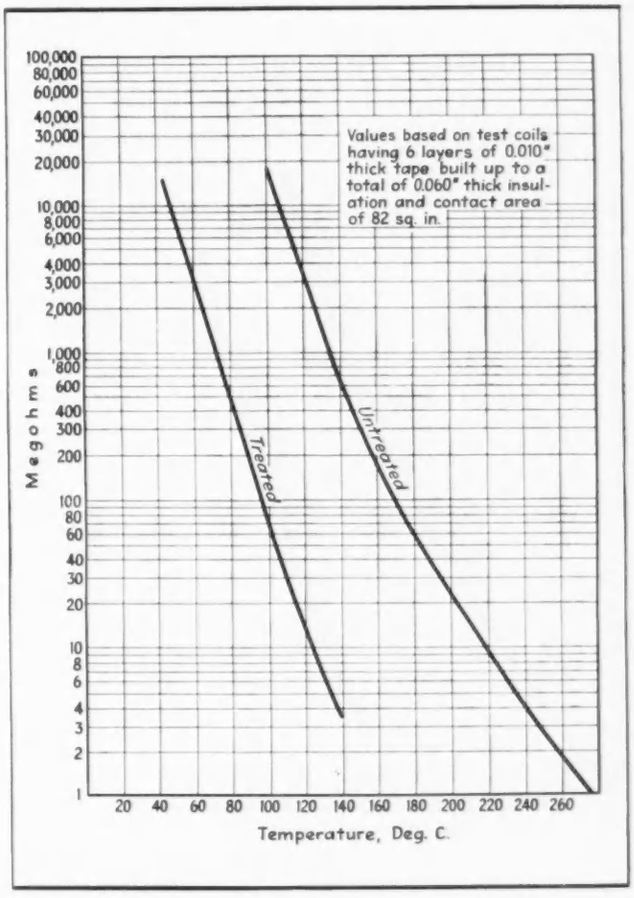

Values based on test coils having 6 layers of 0.010" thick tape built up to a total of 0.060" thick insulation and contact area of 82 sq. in.
Untreated
Treated
Megohms
Temperature, Deg. C.

Fig. 3—Curves showing effect of temperature on insulation resistance of treated and untreated glass tape

point" is 835 deg. C. The tensile strength of glass tape is shown in Fig. 1, in comparison with cotton and asbestos tape, at various temperatures.

Glass textiles are "non-hygroscopic" because the individual fibers are almost infinitesimal glass rods. The importance of this characteristic is shown in Fig. 2 by curves which illustrate the effect of exposure to humidity on glass and asbestos insulated coils, both of which were treated with the same varnish. A small amount of moisture does find its way into the interstices of the glass fibers but this is of little relative importance, as compared to moisture absorbed by true fibrous materials. It is significant that the coil in Fig. 2 which was insulated with untreated glass eventually stabilized at a higher insulation resistance than the coil with treated asbestos insulation.

Since glass textiles are woven, their inherent di-electric strength in the untreated condition is only comparable to that of similar conventional woven materials. When treated they take on the characteristics of the varnish film as do other woven materials. For this reason glass textiles have not been considered as materials to replace mica for main ground insulation on high temperature (Class B) machinery. Glass fabrics do have an advantage because they are "non-hygroscopic", it is because of this property that the di-electric breakdown is higher than for other materials after both have been exposed to high humidity. Tests indicate an advantage for glass of 1½ to 2 times the di-electric breakdown voltage of other woven materials under humid conditions.

Every material has its weaknesses and disadvantages as well as its desirable features and glass textiles are no exception. One of the present limitations is the relatively low resistance to abrasion when the fibers are not lubricated or supported by impregnation. In tape and cloth form the fibers are lubricated by an oil film applied during manufacture. In the apparatus this must be supplemented by varnish or other impregnant. When this lubricant or impregnant is eliminated or its qualities destroyed, vibration is likely to cause abrasive destruction.

Another limitation is the relatively low shear strength of the glass fibers. To avoid shearing, apparatus should be designed so as not to expose glass insulation to contacts with sharp corners or edges.

The smooth, silky structure of glass fabrics is in a sense a handicap as it permits the warp to slip on the weft. This can be reduced somewhat by using a closer weave. A practical method has been devised to counteract this tendency by vacuum impregnating the rolls of tape in solventless varnish and only partially curing the varnish.

Much field experience needs to be gathered regarding the life of this new material and its unknown service characteristics; however, it is a much needed and welcome addition to the family of insulating materials. It is believed that this material will be an important factor in future electrical machine design.

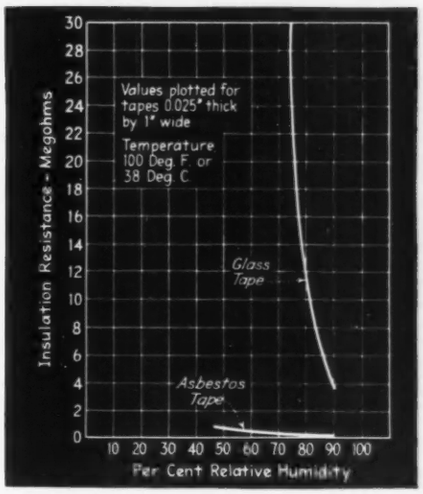

Values plotted for tapes 0.025" thick by 1" wide
Temperature 100 Deg. F. or 38 Deg. C.
Glass Tape
Asbestos Tape
Insulation Resistance - Megohms
Per Cent Relative Humidity

Fig. 4—Insulation resistance of glass and asbestos tape at various humidities

ELECTRICAL CONTACTS

Factors Affecting Their Life and Performance

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P. R. Mallory & Company, Inc.

Part I. An analysis of the effects of inductance, contact pressure and peak voltage on the current capacity and transfer tendency of fine silver contacts when used in d.c. circuits

BROADLY, this article is concerned with the effect of inductance in low voltage, direct current circuits on the life of silver and tungsten contacts. The discussion in this first part is quite general since it is intended to show the effects of inductance, contact pressure, and peak voltage on the current capacity and transfer tendency of fine silver contacts. In the second part, which will appear in a future number, the behavior of tungsten contacts as governed by various protective condenser values will be discussed. From these data, explanations of behavior are derived which are thought to be a contribution to the existing knowledge on tungsten contacts. The second part will also deal with the development of a new differential contact combination which has been successful in eliminating contact troubles on such devices as voltage regulators operating at low voltage.

Selection of a contact material for optimum life conditions at minimum cost involves full consideration of many factors:

A. Electrical Conditions

Voltage across the contacts
Current through contacts
Alternating or direct current
Type of load
  Resistive, Inductive, Capacitive, Lamp-metal filament
Condenser or other, protection for contacts

B. Mechanical Conditions

Contact pressure
  Static pressure with contacts closed
  Impact pressure at instant of closure
  Operating pressure, if contacts vibrate at high frequency
Frequency of operation of contacts
  Number of "makes and breaks" per unit of time
Long "off" periods with contacts open
Method of operating contacts
  Mechanical, e.g., by cam
  Electrical as by coil and armature
Wipe—or slide—between contacts on closure
Chatter on opening contacts, or bounce during closure
Acceleration of contacts during opening and closing
Contact spacing when fully open
Atmosphere in which contacts operate
  Humidity, Corroding gases or fumes, Salt air, Dirt, Operation in inert or reducing atmosphere
Contacts in open, covered, or sealed
Ambient temperature in contact region
Length of time contacts are open and time during which they carry current
Possibility of contamination from adjacent parts of apparatus

C. Cost Factors

Allowable ratio of contact cost to apparatus cost
Size of contacts required
Shape of contact and tolerances on size
Type of contact material selected
Kind of backing material required, if contact material cannot be used in solid form
Method of fabricating contact
Method of assembling contact into apparatus

This list necessarily is not complete, but it indicates the factors involved in making an intelligent selection of contact materials. It is quite impossible, in fact undesirable, to discuss all these factors, within the limits of this article. However, it is feasible to cover the effect of the more important factors on the life of the contacts.

In this section, "limiting current" is taken to mean the current at which the contacts weld, or stick together during operation, and "transfer" is the term used to describe the phenomenon in which part of the material of one contact transfers onto the mating contact thereby leaving a pit or crater in the

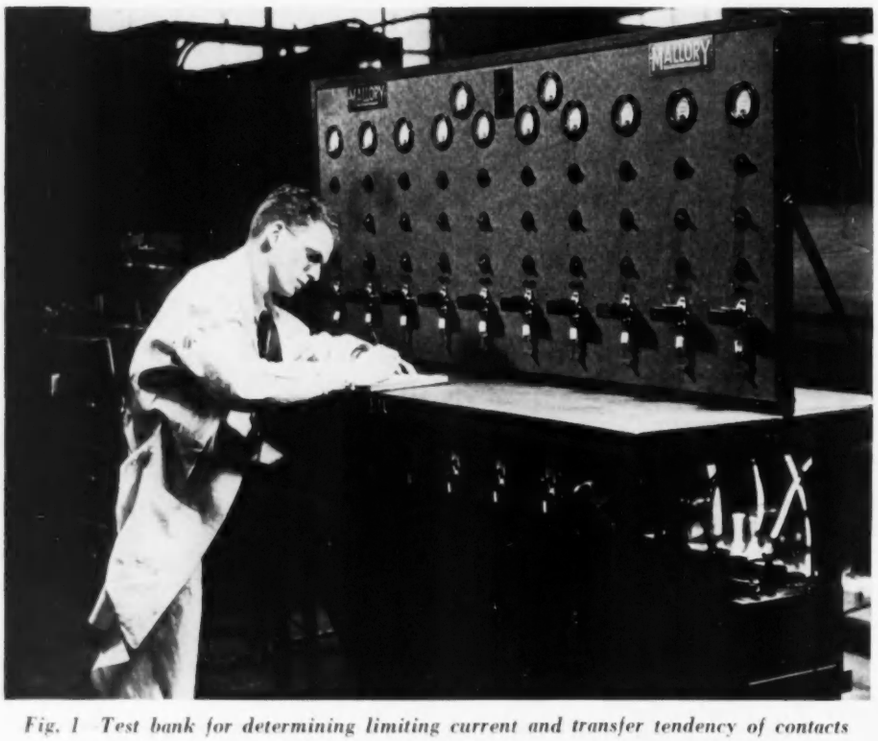

Fig. 1—Test bank for determining limiting current and transfer tendency of contacts

contact from which the transfer has taken place.

Limiting current and transfer are two of the more important criteria by which contact performance may be judged. Other bases of evaluation are contact resistance or contact voltage drop, tendency to disintegrate under heavy arcing and resistance to mechanical wear.

With regard to limiting current and the general subject of contacts sticking together, no distinction is made between types of sticking caused by actual welding or by contact roughness. Also, no reference is made to the type of transfer which may be characterized by such terms as dome-shape, ridge, peak, or general roughness. The last type has been called "fine transfer" in the German literature, apparently referring to the state of subdivision of the transferred material.

Limiting current of a material, to be fully descriptive, should be accompanied by information on the voltage, contact pressure, release tension, frequency of contact operation, type of load, contact spacing, contact protection devices and method of operation of the contacts.

Transfer Tendency

Transfer tendency is an important property of a material, since it may change the contact spacing or otherwise inhibit the free operation of the apparatus using the contacts, thereby disturbing the calibration or accuracy of performance.

To determine the limiting current and transfer tendency of a large number of contact materials, test panels like that shown in Fig. 1 are used. Fig. 2 shows the wiring diagram for the test set. The arrangement makes it conveniently possible to study the effect of voltage, current, inductive or resistive load, contact pressure, contact frequency, and contact size.

The test contacts are staked into the relays shown on the panel front. By adjustment of the relay, it is also possible to study the effect of contact spacing, "bounce" during closure of contacts, and contact wipe.

Magnetically-operated relays are used. These relays are actuated by low-voltage direct current from storage batteries, and a separate set of batteries is used to load the contacts. The actuating voltage is interrupted by means of a segmented pulley; therefore, the rate of operation of the contacts may be controlled by the pulley speed.

In this test, the load can be made resistive or highly inductive by means of the selector switches on the panel. The load rheostat is also panel-mounted. Contact pressure is adjusted by changing the tension on relay spring, altering the core-to-armature gap, or adjusting the actuating coil voltage as required.

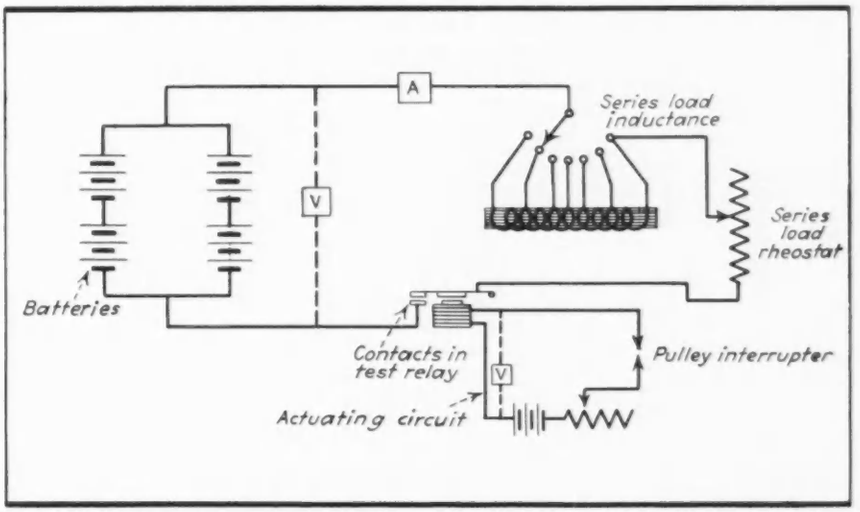

Fig. 2—Circuit used in test panel to determine magnitude of limiting current and transfer of contact material

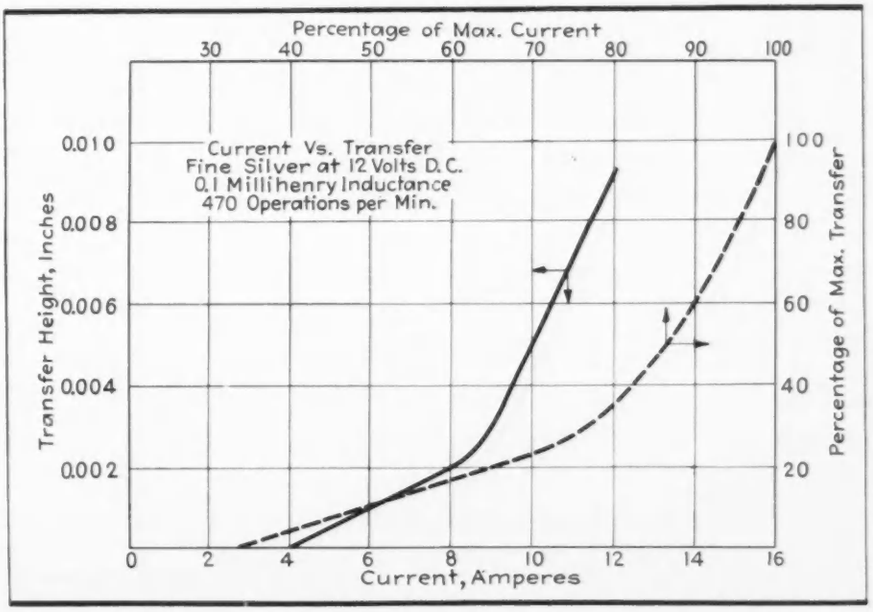

Fig. 3 – Effect of current on the height of transfer between silver contacts

The illustration does not show the oscilloscope or the method of measuring contact resistance. These observations are conveniently made, however, by simply running connections directly to the relay. A portable panel, containing a low-range voltmeter and ammeter, is placed next to the test panel for contact resistance measurements.

Test data on silver contacts were obtained under the following conditions on the above-described test set:

Contact Material: Fine Silver—99.9 per cent pure
Voltage: 12 volts d.c.
Current: Started at 3 amp. and increased one amp. every 4 min. without stopping test until contacts failed by sticking
Transfer: Measured on comparator after above-noted failure. May be observed during test also
Contact Pressure: 150 grams (except Fig. 4)
Release Tension: 150 grams (except Fig. 4)
Load: As indicated in Fig. 3, 4, and 5
Frequency: 470 makes and breaks per min.
Contact Spacing: 0.027 in.
Contact Wipe: None
Contact Bounce: Two bounces per contact make
Contact Size: 0.218 in. diam. x 0.045 in. head thickness

Some of the information obtained by such tests is reported below since it may be helpful in design problems. Fig. 3 shows the effect of current on the height of transfer between silver contacts operated under the above conditions with a 0.1 millihenry inductance in series with the load rheostat.

All transfer was to the negative con-

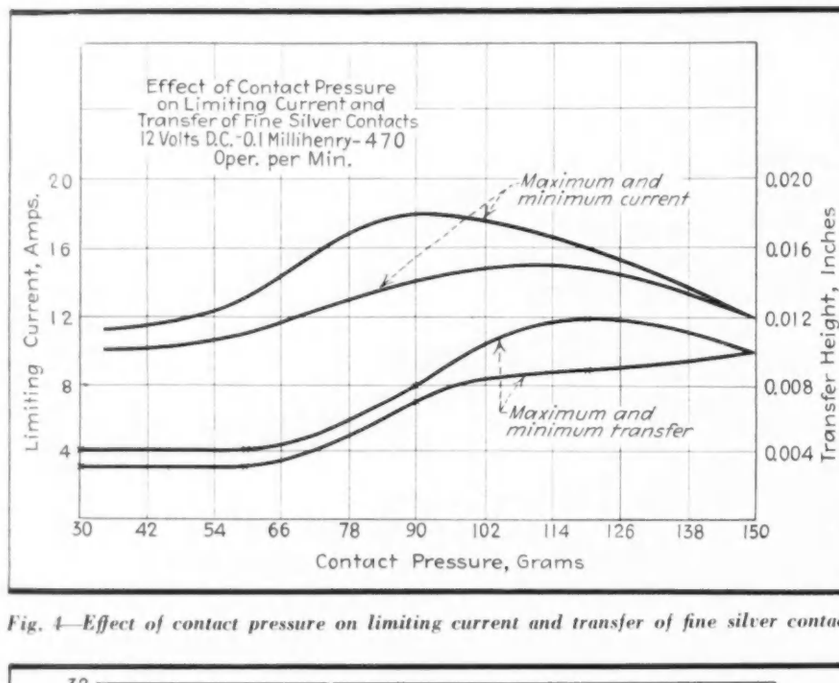

Fig. 4—Effect of contact pressure on limiting current and transfer of fine silver contacts

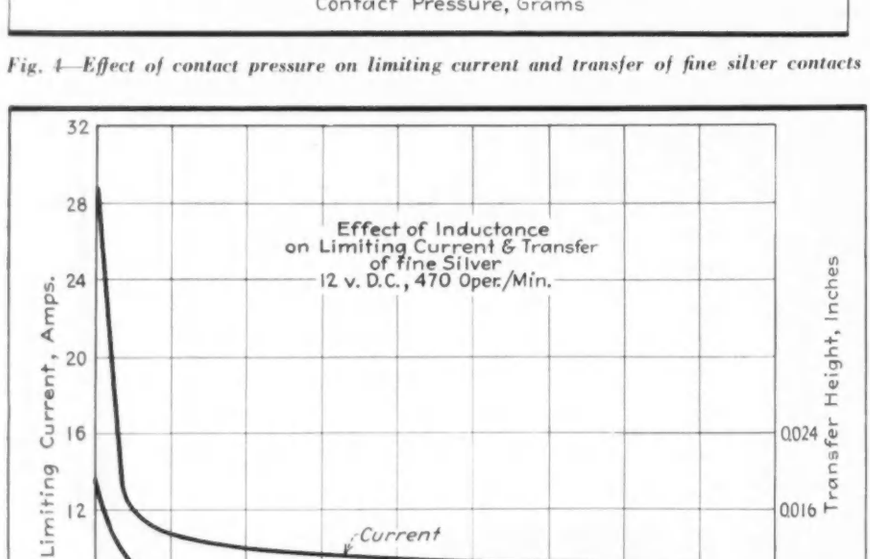

Fig. 5—Effect of inductance on limiting current and transfer of fine silver contacts

tact (cathode). It will be noted that the transfer vs. current relation is a straight line to about 8 amp. Above this current value, the transfer increases more rapidly up to 12 amp. which is the current at which the contacts stuck.

It may be said, therefore, that the amount of transfer is a direct function of the current, and that the critical point for fine silver is 8 amp. It therefore appears desirable, where transfer is objectionable to performance, to limit the current to some value below 8 amp. per contact pair, when the circuit conditions are approximately as outlined.

Silver alloys have been found in these investigations which have much lower transfer tendencies. Such alloys often give a more ready answer to design problems than can be obtained by redrawing the mechanical or circuit conditions. For example, it has been found that an Ag-Cd-Ni alloy (Elkonium 17, U. S. Pat. No. 2,080,811) has a transfer of only 0.003 in. under the same test conditions as above with a limiting current substantially equal to that of fine silver.

Tungsten-Silver Material

Other materials now are also available for this purpose. A high tungsten-silver material (Elkonite 20S, U. S. Pat. No. 1,860,793) may be used which transfers 0.0035 in. in this test, but with a limiting current 60 per cent higher than that of silver alone. These are several examples of what may be done in solving contact problems, strictly aside from the possibilities of apparatus design.

Another variable, contact pressure, affects the limiting current and transfer of fine silver contacts, as shown in Fig. 4. These results were obtained under conditions identical with those of Fig. 3, except that the contact pressure and release tension were changed as shown.

This indicates that the optimum range of pressure for fine silver is about 90 to 120 grams where limiting current is a factor, and 60 grams where transfer is the dominant criterion of performance. This is certainly true where the operating conditions are similar to those of the test. The data seem to offer a good starting point for design, in any case where relays are involved. It has been noted, however, that test results are a little more consistent at 150 grams, as shown by the maximum-minimum lines at lower pressure.

Contact Resistance

In connection with the matter of contact pressure, there is another factor to be kept constantly in sight. This is the effect of contact resistance. It can be shown that as the contact pressure falls, the contact resistance (voltage drop) increases. This is particularly true:

Below 40 grams contact pressure
At low impressed voltage
At low current values
In the absence of a small amount of arcing
When the contact material contains an element which produces a persistent oxide

Therefore, in using a material such as tungsten, especially in low voltage circuits, it is usually essential to have a high contact pressure in order to nullify the effect of oxides and keep the contact temperature within bounds. Fig. 5 illustrates the effect of inductance on limiting current and transfer. It will be noted that both these values decrease as the inductance increases. That is, an increase in load circuit inductance decreases the current capacity of fine silver as well as the transfer. The reduction is most marked in the addition of the first one-tenth unit of inductance, and is more gradual thereafter. Transfer is most marked on resistive loads. It is possible to obtain a better material from the standpoint of transfer in resistive load circuits. An alloy of Ag-Ni-Cu (Elkonium 1, U. S. Pat. No. 2,037,446) will reduce the transfer of fine silver by 95 per cent with a loss of only 15 per cent in current capacity. Ternary alloys of silver with noble metals will do the same to the transfer with little loss, or an increase, in critical current, depending upon metals used as alloying elements.

COLORING OF METALS

By Chemical or Electrochemical Methods

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Part II. In which additional methods are presented for coloring metal products and parts wherein the base metal or alloy from which the object is made becomes part of the coating produced

METHODS of coloring articles made of aluminum, cadmium and chromium by dipping the products in chemical solutions or salts were described in Part I of this article which apeared in the February issue of *Product Engineering*.

This installment of the article deals with methods and solutions used to produce colored coatings on copper, brass, gold, iron, steel, lead, magnesium, nickel and cobalt.

COPPER and BRASS. These materials are comparatively simple to color as their salts are colored. They can be colored in many different ways and many coloring formulas can be listed. Only a few of these are listed here.

Copper can be colored green with a solution containing

Cupric nitrate, $Cu(NO_3)_2$ (*40 grams per liter*)

Ammonium chloride, NH_4Cl (*40 grams per liter*)

Calcium chloride, $CaCl_2.2H_2O$ (*40 grams per liter*)

Copper can be colored brown with the following solutions:

SOLUTION I

Barium sulfide, BaS (*15 grams per liter*)

SOLUTION II

Ammonium sulfide, $(NH_4)_2S$ (*25 grams per liter*)

SOLUTION III

Cupric chloride, $CuCl_2$ (*200 grams per liter*)

Temperature (*80 deg. C.*)

SOLUTION IV

Potassium chlorate, $KClO_3$ (*8 grams per liter*)

Cupric sulfate, $CuSO_4.5H_2O$ (*28 grams per liter*)

Temperature (*175 deg. F.*)

Copper can be colored blue or purple with the following solutions:

SOLUTION I

Sodium hyposulfite, $NaHSO_2$ (*60 grams per liter*)

Nitric acid, HNO_3, sp. gr. 1.24 (*4 cc.*)

SOLUTION II

Potassium chlorate, $KClO_3$ (*100 grams per liter*)

Ammonium nitrate, NH_4NO_3 (*100 grams per liter*)

Cupric nitrate, $Cu(No_3)_2$ (*2 grams per liter*)

Copper can be colored black with the following solutions:

SOLUTION I

Potassium sulfide, K_2S (*15 grams per liter*)

Ammonium chloride, NH_4Cl (*200 grams per liter*)

The sodium salt may be substituted for the potassium salt. However, it has been the experience of the author that the latter gives blacker deposits than the former.

SOLUTION II

Hydrochloric acid, sp. gr. 1.3 (*75 cc.*)

Arsenious acid, As_2O_3 (*30 grams per liter*)

Sulfuric acid, sp. gr. 1.84 (*8 cc. per liter*)

Temperature (*175 deg. F.*)

Brass can be colored green with the following solutions:

SOLUTION I

Cupric sulfate, $CuSO_4.5H_2O$ (*75 grams per liter*)

Ammonium chloride, NH_4Cl (*12.5 grams per liter*)

SOLUTION II

Ferric nitrate, $Fe(NO_3)_3$ (*15 grams per liter*)

Sodium bisulfite, $NaHSO_3$ (*60 grams per liter*)

Temperature (*200 deg. F.*)

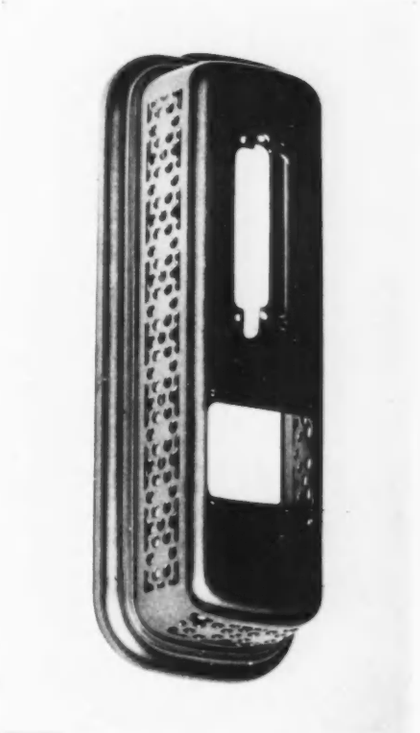
SOLUTION III

A rather interesting apple green can be obtained by making the brass the anode, see Platers Guidebook, p. 32, 1937, in a solution containing:

Cupric sulfate, $CuSO_4.5H_2O$ (*100 grams per liter*)

Potassium bichromate, $K_2Cr_2O_7$ (*60 grams per liter*)

The bath is used at 80 deg. F. with lead anodes using 6–8 volts. By varying the amounts of the materials in the bath, a green was obtained which adhered well except near the edges of the object being colored. This is undoubtedly the result of the excessive current density which is prevalent at these points. More research is needed on this bath in order to produce a coating which is uniform.



Philip Sievering Inc.
Thermostat housing made of a steel stamping bronze plated and scratch-brushed

Brown coatings can be produced on brass with any of these solutions:

SOLUTION I

Potassium sulfide, K_2S (*10 grams per liter*)

SOLUTION II

Barium sulfide, BaS (*12 grams per liter*)

SOLUTION III

Cupric sulfate, $CuSO_4.5H_2O$ (*25 grams per liter*)

Nickel ammonium sulfate, $NiSO_4(NH_4)_2SO_4.6H_2O$ (*25 grams per liter*)

Potassium chlorate, $KClO_3$ (*25 grams per liter*)

Temperature (*200 deg. F.*)

Yellow coatings can be produced on brass with a solution of:

Ammonium sulfide, $(NH_4)_2S$ conc. (*100 cc. per liter*)

Blue or purple coatings can be produced on brass with these solutions:

SOLUTION I

One of the best solutions for producing a deep dark blue on brass consists of immersing the brass in a solution containing:

Cupric carbonate, $CuCO_3$ (*125 grams per liter*)

Ammonium hydroxide, NH_4OH, sp. gr. 0.88 (*250 cc.*)

It has been found that a very small amount of sodium hydroxide, not enough to produce a precipitate of $CU(OH)_2$, produces a coating which is harder and does not oxidize as easily as those produced without this material.

SOLUTION II

Sodium hyposulfite, $NaHSO_2$ (*60 grams per liter*)

Lead acetate, $Pb(Ac)_2$ (*30 grams per liter*)

Temperature (*200 deg. F.*)

Black coatings can be produced on brass with a solution containing:

Cupric sulfate, $CuSO_4.5H_2O$ (*30 grams per liter*)

Ammonium hydroxide, sp. gr. 0.88 (*Add until only slight precipitate remains.*)

Temperature (*175 deg. F.*)

The above colored coating should be "fixed" by passing through a solution containing:

Sodium hydroxide, NaOH (*20 grams per liter*)

Copper and brass may also be colored by depositing a thin film of another metal or alloy over their surfaces. Thus, these may be transformed into a silver white material by depositing on their surfaces a layer of nickel, nickel-cobalt alloy, and chromium.

Copper when alloyed with different metals produces alloys with various colors. Thus, it is possible to produce alloys varying in colors as dark bluish gray, silver gray, silver white, dull yellow, yellow and yellow red by adding various amounts of zinc to copper. Similar colors can be obtained by adding different amounts of tin to copper. Copper can be converted into a white alloy by adding different amounts of nickel. This alloy is used in large amounts and is known as nickel silver.

As has been pointed out earlier, the alloy of copper and aluminum (Cu 92 per cent, Al 8 per cent) has an attractive yellow gold color and good corrosive resistance properties.

By selecting the various alloys of copper, many interesting and attractive designs can be produced. One that has been a favorite for many years is made of copper for the background and yellow brass as the trimming material.

GOLD. This metal, with its soft yellow color and non-corrosive properties, has long been used as a decorative material. Because of its cost, it is used only in small amounts if at all possible. At present there are few demands to change the color of this element as the public is now demanding the "old gold" color. This metal may be deposited from the cyanide solution containing:

Metallic gold as the cyanide (*5 pwt. per gal.*)

Potassium cyanide, KCN (*2 oz. per gal.*)

Tri sodium phosphate, Na_3PO_4 (*5 oz. per gal.*)

Current Density (*2–10 amp. per sq. ft.*)

Temperature (*175 deg. F.*)

Green, white, and various shades of yellow gold may be deposited by adding various amounts of nickel, silver, copper and zinc. These shades of color can further be varied by using different current densities, temperatures and concentrations of the salts in the bath.

IRON and STEEL. These materials are colored both for appearance and protection against corrosion. One of the best ways of producing various colors on steel is to heat to different temperatures. In this way an oxide coating is produced which gives rise to many colors.

Color	*Degrees F.*
Pale yellow	420
Straw yellow	440
Brown	490
Purple	536
Pale Blue	570
Dark Blue	600

Often the objects are heated in salt or sand baths so as to control closely the temperature of the object. A good salt bath consists of equal parts of sodium and potassium nitrate to which is added manganese dioxide in the ratio of 1 oxide to 50 nitrate mixtures.

Black coatings can be produced on iron and steel with these solutions:

SOLUTION I

Sodium thiosulfate, $Na_2S_2O_3$ (*30 grams per liter*)

Temperature (*200 deg. F.*)

SOLUTION II

Sodium hydroxide, NaOH (*400 grams per liter*)

Potassium nitrate, KNO_3 (*10 grams per liter*)

Sodium nitrate, $NaNO_3$ (*10 grams per liter*)

Temperature (*250 deg. F.*)

SOLUTION III

Cupric sulfate, $CuSO_4.5H_2O$ (*150 grams per liter*)

Nitric acid, HNO_3 sp. gr. 1.35 (*300 grams per liter*)

Ethyl alcohol, C_2H_5OH (*600 cc. per liter*)

The cleaned articles are immersed in the above solutions and then allowed to dry in the air. When dried, they are rubbed with cloths containing oil which helps to darken the color of the coating.

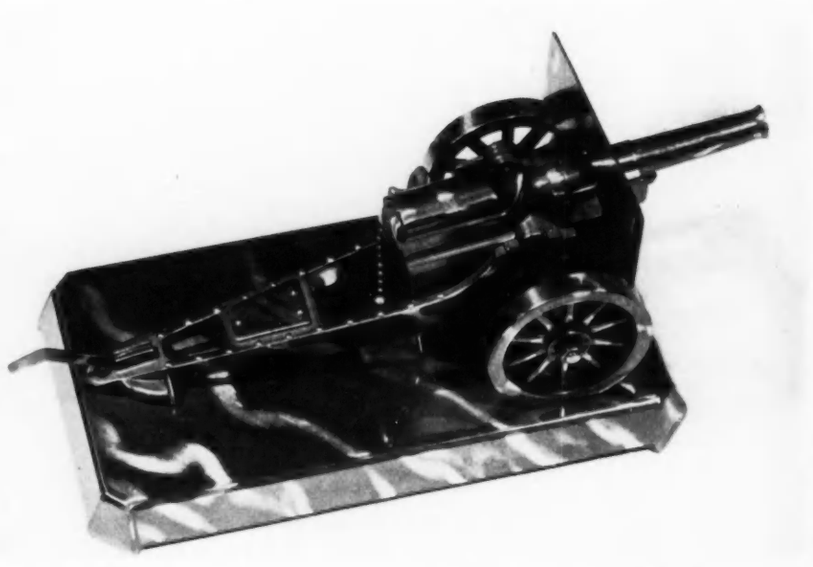
Sodium nitrite has been found to be of considerable importance in obtaining black coatings on steel. This material can be used in aqueous solutions and produces very good results. The author has produced some attractive black coatings using this salt.

Blue coatings can be produced on iron and steel with a solution containing:

Sodium bisulfite, $NaHSO_3$ (*60 grams per liter*)

Lead acetate, $Pb(Ac)_2$ (*15 grams per liter*)

Temperature (*200 deg. F.*)



Novelty cigarette lighter made up of steel stampings and zinc die-casting which are brass plated and "oxidized" then buffed for high lights *Philip Steering Inc.*

Steel screws colored blue black by immersion in an aqueous solution, coating is corrosion resistant and attractive

It is possible to color iron and steel various shades of red, yellow and brown by producing on their surfaces the different oxides. However, unless precautions are taken, the deposits produced are non-adherent and will crumble away from the base metal.

Iron and steel may be colored red by depositing a layer of copper on the surface, yellow by depositing brass, and black by depositing black nickel. It is also possible to deposit a layer of copper or brass and then color this deposit as already outlined under "copper and brass." A black nickel bath that produces a deep black or gray deposit on iron or steel in fifteen to twenty minutes, consists of:

Nickel ammonium sulfate, $NiSO_4(NH_4)_2SO_4.6H_2O$ (*60 grams per liter*)
Zinc sulfate, $ZnSO_4.7H_2O$ (*15 grams per liter*)
Sodium sulfocyanide, NaCNS (*15 grams per liter*)
pH (*5.5*)
Temperature (*80 deg. F.*)
Current Density, (*2 amp. per sq. ft. produced at 1–1.5 volts*)

The deposit is a mixture of nickel, zinc, nickel, sulfide and some unknown organic compound. The bath requires control at all times and unlike most deposits, it requires the regulation of the voltage and not the amperage.

Hardly any alloys of iron are colored. True, the stainless steel group are important alloys of this material, but these all are silver white in color.

LEAD. This material, because of its softness and poor resistance to abrasion is little used in industry. It can, however, be colored by depositing other metals on its surface and then treating them as herein described.

MAGNESIUM. This material, because of its light weight, bids to become widely used in the construction of parts for household appliances and for aircraft. Some research has been carried on of late at several institutions which has produced some interesting results. It is possible to produce ebony black coatings on this material by making it the anode in the following solutions:

SOLUTION I
Chromic acid, CrO_3 (*100–200 grams per liter*)
Tri sodium phosphate, Na_3PO_4 (*100–250 grams per liter*)
pH (*3 approx.*)
Temperature (*75–200 deg. F.*)
Current Density (*15–30 amp. per sq. ft.*)

SOLUTION II
Sodium dichromate, $Na_2Cr_2O_7$ (*10 per cent*)
Sodium hydrogen phosphate, NaH_2PO_4 (*2–5 per cent*)
Current Density (*5–10 amp. per sq. ft.*)
Temperature (*122 deg. F.*)
pH (*4–4.8*)

It has been found that Solution I gives coatings which vary in color from a dull gray to a bright ebony black. The general conditions are given in the formula above. It is possible by maintaining constant conditions to produce the glossy black deposit without any trouble. However, the characteristics of the coating are dependent largely upon the pH of the solution. This can be checked best by using a glass electrode. The first bath has been found to impart a black coating to tin also.

NICKEL and COBALT. These elements are not generally used as base metals but the first is used extensively as a coating for the more active metals. The electrodeposits can be colored gray or black by immersing in the following solution:

Ammonium chloride, NH_4Cl (*50 grams per liter*)
Ammonium sulfide, $(NH_4)_2S$, (*Concentrated*)

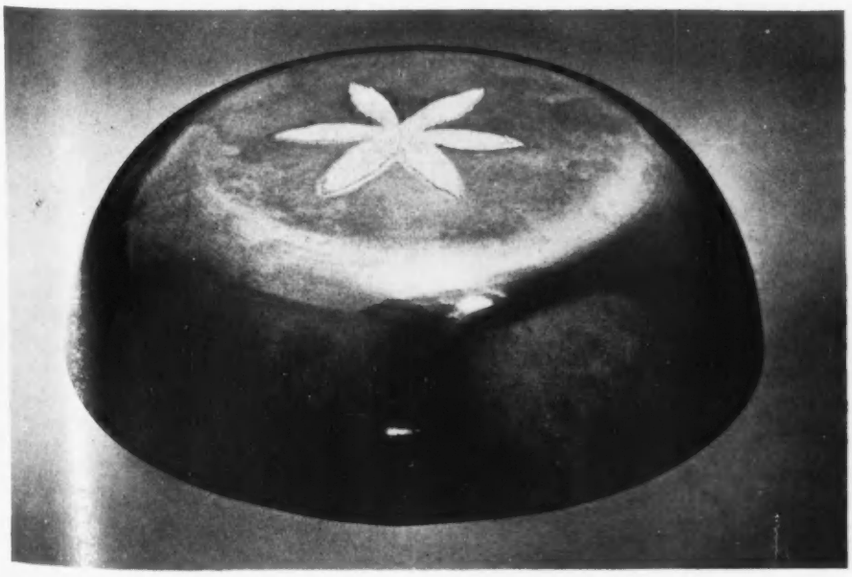
The black nickel bath will impart a lustrous black to these materials.

A rather interesting alloy can be deposited by combining nickel and cobalt in a sulfate bath. The author has worked out an alloy plating solution which deposits these metals in a 50–50 ratio. The resulting alloys have many advantages over the usual nickel. These are—

(*a*) A silver white alloy is produced.
(*b*) Is more resistant to corrosion.
(*c*) Does not assume the yellow stains as does nickel when stored.
(*d*) Serves as an excellent undercoating for chromium as it does not become passive.

This alloy is very attractive since its color approaches silver, because the nickel color which has a yellowish tinge is neutralized by the cobalt which has a bluish tinge. These unite to give one of the closest approaches to silver that is known. The bath is commercial even for barrel plating and small pieces may thus be plated without the expensive racking. The bath generally contains a nickel cobalt ratio of 90 per cent nickel as nickel sulfate and 10 per cent cobalt also as the sulfate. These deposits are being utilized in many ways for covering brass, bronze and steel. In using this bath it is essential to control the current density, temperature, concentration and pH in order to produce coatings which are uniform in composition.

Copper dome (laboratory sample) with design formed by covering metal with paper stencil, sand blasted then sprayed with aluminum



MULTI-SPEED MOTORS

Speeds Available, Characteristics and Classifications

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Engineering Department, Wagner Electric Corporation

How to select the proper type of multi-speed polyphase squirrel-cage induction motor for driving machines that require several operating speeds, including a discussion of controls

WHEN A MOTOR driven machine must be operated at several different speeds, usually the various speeds can be obtained most economically and satisfactorily by the use of multi-speed polyphase squirrel-cage induction motors. According to the definition adopted by the American Standards Association, "A multi-speed motor is one which can be operated at any one of two or more definite speeds, each being practically independent of the load." Multi-speed motors may be classified according to windings and torques and may be built with a large variety of electrical and mechanical modifications.

An ordinary single speed squirrel-cage motor has a winding which fills all the stator slots and is connected to produce a definite number of poles and therefore a definite rotor speed at a definite supply voltage and frequency. It is obviously possible to provide a stator of greater physical dimensions with a winding which does not fill the slot and to place a second winding in the remaining slot space. The latter winding may be connected for a different number of poles and produce a second rotor speed and such a motor is known as a two-speed, two-winding motor. This is the simplest multi-speed motor and the operating speeds may be any of the usual commercial values. When such a motor is intended for operation on a three-phase circuit, each winding is ordinarily provided with three leads. When intended for use on a two-phase circuit, each winding usually has four leads. When one winding is connected to the source of supply, the other winding must be open circuited.

There is another method of building two-speed motors which makes use of a single stator winding provided with six leads. By properly connecting these leads to the line and to each other, it is possible to obtain two definite operating speeds, one of which is half the other. Such a motor is known as a two-speed, single-winding motor and is usually built in the frame corresponding to the horsepower and speed of the lower speed rating. It has the advantage of being built in a smaller frame than is required for the two-speed, two-winding motor, but has the disadvantage of requiring more complicated control. Fig. 1 shows the development of such a winding for a three-phase motor together with the connections and resulting field forms.

The synchronous speeds in r.p.m. which may be obtained from two-speed, single-winding 60 cycle motors are usually limited to the following combinations:

3,600 / 1,800	1,800 / 900	1,200 / 600	900 / 450

Two-speed two-winding motors may also be built with any two of the above

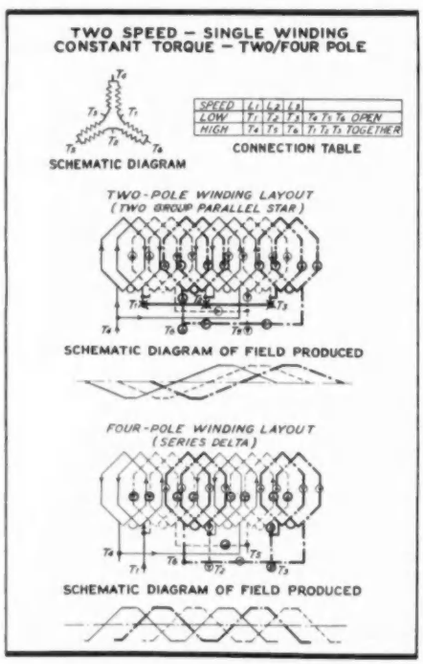


Fig. 1—Scheme and development of a winding for a three-phase two-speed motor which makes use of a single stator winding provided with six leads

speeds, and two windings are always required if one of the desired speeds differs from those above or if the two speeds are not in a 2 to 1 ratio.

Two windings are always required for two-phase motors, except for fan and blower applications where the speed ratio is 2 to 1, therefore further references to single-winding motors will apply only to three-phase machines.

A three-speed motor may be built using three separate windings and such a motor is known as a three-speed, three-winding motor. This type of motor is not recommended by most manufacturers, because the winding space must be divided into three parts for the three windings and too much of the space is taken up with insulation and winding clearances. The frame size required for three-winding motors is larger than for two-winding motors. Most three-speed motors are built with two windings, one of which may be regrouped as shown in Fig. 1. The two speeds produced by the one winding must have a ratio of 2 to 1, while the third speed need bear no relation to the first two.

The synchronous speeds which may be obtained from three-speed two-winding 60 cycle motors are usually limited to the combinations given above for two-speed, single-winding motors plus one other speed of any commercial value.

Four-speed motors are generally wound with two of the regroupable windings shown in Fig. 1, and the 60 cycle synchronous speeds in r.p.m. are usually limited to the following:

(*a*)	(*b*)
1,800	1,200
1,200	900
900	600
600	450

Three-speed motors are seldom specified unless one of the desired speeds differs from the above values.

If the turning effort or torque required by the drive is approximately the same regardless of speed, the application requires a constant torque motor. Most machine tools, compressors and general purpose applications require this type of motor. The windings of these motors are designed to produce similar characteristics at each speed, that is, the starting

and maximum torques at the several speeds are practically the same. Since horsepower output is proportional to the product of torque and speed, the horsepower output of a constant-torque motor varies directly as the speed. For example, a two-speed, constant-torque 1,800/900 r.p.m. motor rated 20 hp. at 1,800 r.p.m. would be rated 10 hp. at 900 revolutions per minute.

The load characteristics of centrifugal pumps and fans or blowers, except positive pressure blowers, require a turning effort which varies almost directly as the speed. Such applications use what is termed a variable-torque motor. The windings of this type motor are designed to produce starting and maximum torques proportional to the speed, and the horsepower at the several speeds therefore varies as the square of the speed. For example, a two-speed variable torque 1,800/900 r.p.m. motor rated 20 hp. at 1,800 r.p.m. would be rated 5 hp. at 900 revolutions per minute.

A few applications require a still different type of motor design. For instance, lathes are frequently designed to take a heavy roughing cut at a low speed and this roughing cut requires a greater turning effort than the finishing cut which is made at a higher speed. The turning effort therefore is approximately inversely proportional to the speed and the drive requires a constant-horsepower motor. For this type of motor the windings are designed to produce starting, maximum and normal full load torques inversely proportional to the speeds and hence the horsepower output is constant. For example, a two-speed constant-horsepower 1,800–900 r.p.m. motor rated at 20 hp. at 1,800 r.p.m. would also be rated 20 hp. at 900 revolutions per minute.

Tables I and IA show the required frame sizes and the torque values for general purpose two-speed two-winding, two-speed single-winding, and single-speed motors. The comparison is made using 20 hp. at 1,800 r.p.m. as top rating.

Because different applications require various torque characteristics, the National Electrical Manufacturers Association have standardized on several distinct types of squirrel-cage induction motors. These types are defined under MG50–119. Principal types are:

CLASS A

Normal Torque, Normal Starting Current, Squirrel-Cage Motor

A normal torque, normal starting current, squirrel-cage motor is a squirrel-cage induction motor with normal starting torque and low slip at the rated load.

CLASS B

Normal Torque, Low Starting Current, Squirrel-Cage Motor

A normal torque, low starting current, squirrel-cage motor is a squirrel-cage induction motor which develops normal starting torque at relatively low starting current. . . . The slip at rated load is relatively low.

CLASS C

High Torque, Low Starting Current, Squirrel-Cage Motor

A high torque, low starting current, squirrel-cage motor is a squirrel-cage induction motor which develops relatively high starting torque at relatively low starting current. . . . The slip at rated load is relatively low.

CLASS D

High Slip Squirrel-Cage Motor

A high slip squirrel-cage motor is a squirrel-cage induction motor in which starting current is limited by relatively high slip at rated load.

Multi-speed motors are obtainable with any of the operating characteristics listed in Table II. Table III lists typical applications for each of the several types.

Table II gives a composite picture of the Class A, B, C and D motors and also includes the wound-rotor slip-ring polyphase induction motor which is sometimes used for adjustable speed operation. The disadvantages of operating a wound-rotor polyphase slip-ring induction motor at reduced speeds are: (1) It requires overmotoring on the high speeds unless the load is a fan, conventional type blower, centrifugal pump or

TABLE II—CHARACTERISTICS OF INDUCTION MOTORS

Type of Motor	Operating Speed	Starting Torque
Single-speed squirrel-cage induction	Practically constant	Low Normal High with low slip High with medium slip High with high slip
Wound-rotor induction	Adjustable but varies considerably with load	Any starting-torque up to maximum torque of motor
Multi-speed squirrel-cage induction	Adjustable for two or more different speeds which are practically constant over operating range	Low Normal High with low slip High with medium slip High with high slip

TABLE I—FRAME SIZES REQUIRED FOR MULTI-SPEED MOTORS

HP.	Syn. R.P.M.	No. of Speeds	N.E.M.A. Frame for General Purpose Motor	No. of Windings	Classification by Torque
20 20	1,800 900	2	444	2	Constant horsepower
20 20	1,800 900	2	405	1	Constant horsepower
20 10	1,800 900	2	404	2	Constant torque
20 10	1,800 900	2	365	1	Constant torque
20 5	1,800 900	2	365	2	Variable torque
20 5	1,800 900	2	364	1	Variable torque
20	1,800	1	364	1	
20	900	1	405	1	
10	900	1	365	1	
5	900	1	324	1	

TABLE IA—TORQUE VALUE COMPARISONS

	At 1,800 r.p.m.				At 900 r.p.m.			
		Lb. Ft. Torque at Full Voltage				Lb. Ft. Torque at Full Voltage		
Classification by Torque	HP.	Full Load	Locked	Max. Run.	HP.	Full Load	Locked	Max. Run
Constant horsepower. .	20	60	90	120	20	120	180	240
Constant torque.	20	60	90	120	10	60	90	120
Variable torque.	20	60	90	120	5	30	45	60

TABLE III—TYPES OF POLYPHASE SQUIRREL-CAGE MOTORS

N.E.M.A. Class	Typical Applications	Locked Torque	App. F.L. Slip	Locked Current
A	Group or individual drives, for most machine tools, fans, blowers, centrifugal pumps or any application where normal-torque motors are satisfactory.	Varies with square of voltage applied to the motor terminals; approximately 150% of F.L. torque at rated voltage; 96% at 80% voltage; as low as 38% at 50% rated voltage.	3 to 5%	May not meet power companies limitations. All sizes suitable for starting directly across the line. Most suitable for general applications. Best all around performance.
B	Same as Class "A"	Approximately same as Class "A".	3 to 5%	Within many power companies limitations. All sizes suitable for starting directly across the line. Slightly poorer all around performance than Class "A"
C	Crushers, plunger pumps, belt conveyors starting under load, refrigeration and air compressors, mixers and other applications requiring high starting torque.	Varies with square of voltage applied to the terminals; approximately 200 to 250% of full load torque at rated voltage; 130% to 160% at 80%, 85% to 100% at 65% rated voltage.	3 to 5%	Within many power companies limitations. All sizes suitable for starting directly across the line. Current reducing devices ordinarily used on only larger sizes.
D	Punch presses, shears, bull dozers, metal drawing operations, balers and other machinery equipped with flywheels.	About 300% to 350% of full load torque.	7 to 11%	Within many power companies limitations. All sizes suitable for starting directly across the line and current reducing starters can not be used because of nature of application.
	Elevators, cranes, hoists, dumb-waiters.	Approximately 250% of full load torque.	15 to 17%	

similar application, (2) the operating efficiency is low since the reduction in speed is accomplished by introducing resistance in the rotor circuit, (3) the reduced speed will not be constant but will vary with the load, (4) the total size and cost of motor and control are generally considerably larger than a comparable multi-speed polyphase squirrel-cage induction motor.

Multi-speed polyphase squirrel-cage induction motors are available in all the usual types of mechanical construction such as the standard open, drip proof, splash proof, totally enclosed and explosion proof frames and may possess any of the operating characteristics shown in Table II in addition.

Table IV shows typical applications which are successfully operated by multi-speed polyphase squirrel-cage motors.

Control

The control for a two-speed two-winding motor consists of a three-pole double throw switch, or two three-pole switches properly interlocked, with the proper thermal overload protection for each of the windings.

The control required for a single-winding two-speed motor is slightly more complicated and consists of a drum or pole changing switch, and a magnetic contactor with proper thermal overload protection, or it may consist of a five-pole and a three-pole contactor properly interlocked, and provided with suitable overload protection.

The type of motor and control selected governs the total unit cost. For example, two-speed two-windings motors are built in a larger frame than corresponding ratings built as two-speed single-winding motors and therefore the cost of the motor itself is greater. The cost of control for a two-speed two-winding motor is usually less than that for a two-speed single-winding motor in the smaller ratings. Therefore, for some ratings the combined cost of motor and control for two-speed two-winding motors is less than that for a corresponding two-speed single-winding motor. In the larger ratings this price advantage disappears and each case must be considered on its own merits since the motors selected may be either two-winding or single-winding and the control may be manual, semi-magnetic or full magnetic.

If manual control is used, each operation performed to connect the motor to the line must be accomplished manually by the operator, such as opening the line switch, properly setting the pole changing drum or switches used to obtain the proper connections and then reclosing the line switch. If a magnetic contactor is placed between the line switch and the motor is operated by a push button, or the handle on the drum is magnetically interlocked with the line switch, the control is semi-magnetic. Full magnetic control makes use of a multi-station push button and the operator may obtain the desired speed by simply pushing the proper button or the change in speeds may be secured by limit switches. For example, the operator loads the machines and presses the start button. The machine starts at a given speed, continues until a limit switch changes to a second speed at which it operates until another limit switch may reverse the motor, after which a final limit switch removes the motor from the line and brings the machine to rest. A large variety of combinations may be arranged to take care of special requirements.

Multi-speed motors are by no means innovations as they were first manufactured by the Oerlikon Company at Switzerland in 1893. The connections required to produce two-speed single-winding constant-torque, variable-torque and constant-horsepower motors were first standardized by NEMA in October, 1926 (Bulletin 110). The last revision of these connections was made in October, 1938 and appear now as an A.S.A. Standard, C-6-1938. The date when the new standards will be effective has not been set. Some of the old and new standards are shown in the Reference Book Sheets, pages 223 and 224 of this issue, others will be included in the following issue, for the convenience of those interested in the application of multi-speed motors.

In general it may be said that single winding motors should be used where possible because they have (1) smaller frames, (2) lower moment of inertia (which is essential if a reversing operation is required) and (3) better performance.

In conclusion it may be said that where (1) rugged construction, (2) reliable and efficient operation, (3) compactness and (4) constant speed are required for the operation of machines requiring two or more speeds, the multi-speed polyphase squirrel-cage motor is the motor to be selected for the job, and the selection frequently results in a considerable saving in costs.

TABLE IV—TYPICAL APPLICATIONS OF MULTI-SPEED MOTORS

Constant Horsepower	Constant Torque	Variable Torque
Lathes	Bread mixers	Ventilating fans
	Drill heads	
Certain punch presses	Machine tools	Blowers
	Positive pressure blowers	
	Elevators	Unit heaters
	Laundry machinery	
	Stokers	Centrifugal pumps
	Compressors	
	Conveyors	
	Extractors	

SHRINKAGE STRESSES

In Arc Welded Structures

H. V. WENGER, JR.

Design and welding procedure for minimizing stresses at areas in welds where stress concentrations may occur, with residual stress diagrams for the different types of welded joints

This article reports the experiences of the J. D. Adams Company

ARC WELDING is a relatively new production tool possessing many advantages but it is not a cure-all. Certain definite limitations must be observed if arc welding is to be properly used. In reality, arc welding is the casting of molten steel under rather unfavorable conditions. The metal is heated to a molten state, passed through the arc and cooled all in a matter of seconds. Naturally expansion and concentration take place during the rapid temperature change, which means that shrinkage stresses will be present in the weld because of this action.

The rapid temperature changes which take place limit the number of ferrous metals that can be welded. It is a safe rule to assume that steels with a carbon content above 0.35 per cent can only be welded by using special procedure. This is because the higher carbon steels lack the necessary ductility to take care of the shrinkage stresses which occur on cooling. Fortunately for the designer requiring steels with strengths above that of S.A.E. 1035 there are the new high tensile, low alloy steels with yield strengths of approximately 60,000 to 70,000 lb. per sq.in. These steels were developed primarily for welded construction and have minimized the air hardening properties of higher carbon steels. For still higher strengths the designer can specify that the chrome-nickel stainless steels be employed for they are easily welded.

One of the by-products of our recent depression has been the development of shielded electrodes which produce fusion metal having physical properties greatly exceeding those of mild steel. This is the result of the alloying of molybdenum and some manganese from the electrode coating through the arc into the fusion zone and also to the refining action of the slag. In addition the coating produces a gaseous shield about the arc which keeps out the detrimental oxides and nitrides obtained in early bare wire welding.

Modern shielded electrodes deposit metal having a ductility of 20 to 35 per cent in 2 in., and it is this property combined with the higher tensile strengths that makes possible satisfactory production welds free from shrinkage cracks. It is important that the yield strength of the deposited fusion metal be considerably below the tensile strength since high shrinkage stresses can relieve themselves by exceeding the yield strength, thus permitting plastic deformation to take place without cracking.

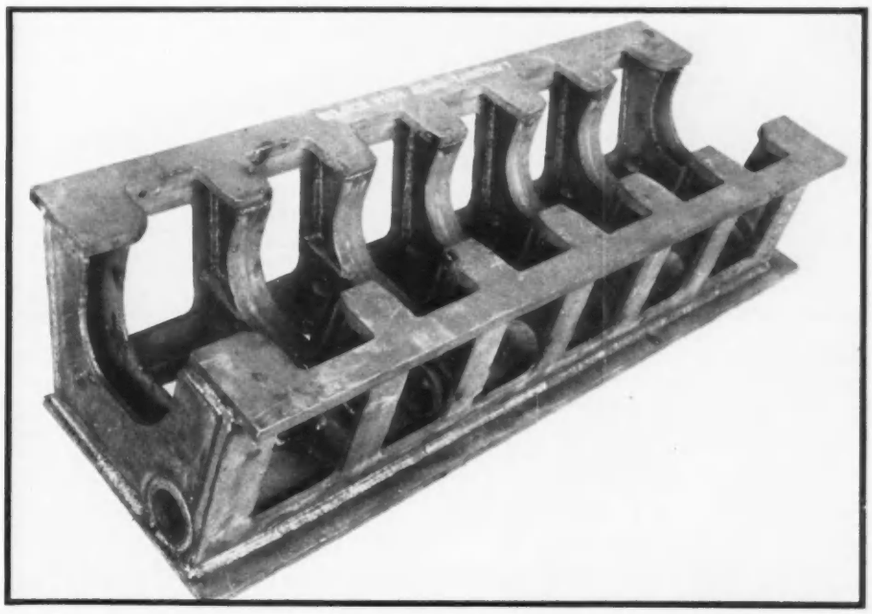
Shrinkage stresses in a welded structure are evident in two forms. The shrinkage may result in distortion of the welded structure or may be confined to residual stresses. The form in which the shrinkage stress appears is determined largely by the amount of restraint on the pieces being welded.

The restraint which causes residual stresses arises from either of two sources; anchorage of the side or ends of the members being welded, or resistance of the parts themselves to distortion during welding. The second source is always present to a certain extent. Distortion is probably a greater evil than residual stresses and can usually be avoided by the use of jigs and by clamping the work to rigid foundations during welding. Avoiding distortion is sure to increase the magnitude of the locked up stresses.

Residual stresses are commonly divided into those parallel to the weld and those perpendicular to the weld. Obviously the stresses may be further classified as to combinations of the two main divisions. However, if the parallel and perpendicular stresses are taken into consideration in the design no further analysis of locked up stresses will be needed.

Considerable research has been done on the subject of residual stresses caused by welding and the literature is full of technical information on the subject. An effort is made here to digest the practical results of the accumulated research (Review of Literature by W. Spraragen and G. E. Claussen and Stress Relieving, by S. C. Hollister) so that the information will be readily available to the designer interested in welded structures.

Residual stresses are present in varying amounts in all structures regardless of whether they are fabricated by arc welding or by other means. The stresses



Diesel engine frame completely fabricated by arc-welding from structural plate

are of no importance in an unloaded structure; but may cause failure when the structure is loaded. The residual stresses will add algebraically to the imposed stresses and the resulting stresses may be dangerously high. The designer therefore must take into consideration both the locked up stresses and the probable load that will be imposed on the structure.

The elimination of residual stresses can nearly always be accomplished, however, their elimination will add materially to the cost of the finished product. Stress relieving may be performed by either thermal or mechanical means. The most common thermal method is to put the whole structure in a furnace which can be heated to 1100-1200 deg. F. for mild steels and higher for alloys. The furnace is brought to temperature and held at that temperature one hour for each inch in thickness of the material being stress relieved. This stress relieving operation is the same as that employed by steel foundries for annealing castings.

Local stress relieving is often employed for high pressure piping systems. Recently induction coils operating from 60 cycle power have been used with considerable success for this operation. Piping is about the only type of work where local stress relieving is employed, since most objects if so treated would distort.

In Europe stress relieving of pressure vessels has been accomplished by filling the tank and applying a pressure that will cause the yield point to be reached in the welded seams. When stressed to the yield point, plastic deformation can take place and locked up stresses relieve themselves.

The welding procedure employed has a great deal to do with the magnitude of the residual stresses and the proper specifying of procedure will often eliminate the need for stress relieving by thermal or mechanical means.

Designers should not expect the shop men to take it upon themselves to use the correct welding procedure for minimizing stresses in welds where stress concentrations may occur. Instead every drawing should specify the type of weld desired, the preparation of the plates, the kind and size of the electrodes to be used, the number of passes to be laid to make up the bead and the sequence to be followed in making the welds.

There are several special procedures that may be employed to minimize the residual stresses. Each one will increase the cost over that required for straight welding and the designer must determine whether the special procedure is necessary. The labor cost is the determining factor in a welded job since the cost of electrodes and power used is comparatively small.

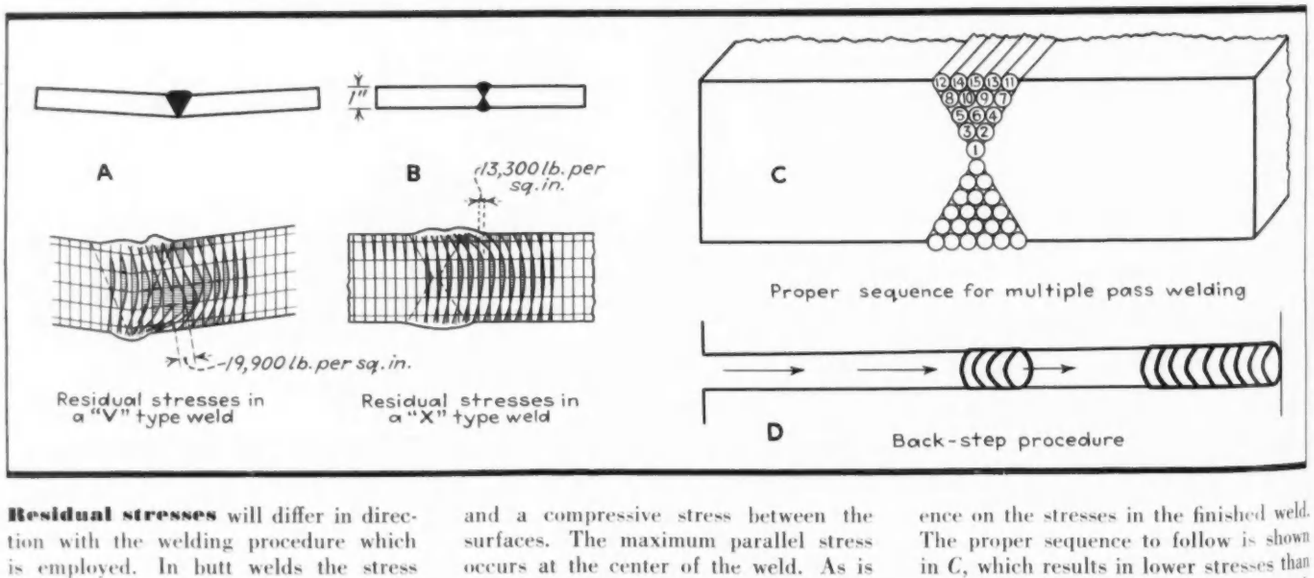
The heat input required for the weld will materially affect the magnitude of the locked up stresses. Therefore, when shrinkage stresses are to be avoided, small electrodes laid in multiple passes using low welding currents should be specified. By peening the passes while they are still hot with a peen hammer or blunt air chisel, the residual stresses can be partially relieved by the plastic deformation which takes place.

Most mild steel structures are subject only to gradually applied loads and the residual stresses are not serious because they will relieve themselves if they reach the yield point. However, where loads are suddenly applied plastic deformation may not have time to take place with the result that the high tensile residual stresses may become serious if the loading involves repeated or reversing stresses.

Often undesirable distortion may result from the release of residual stresses in high temperature service. This applies especially to the fabrication of pressure vessels which must operate at high temperatures and withstand high pressures. Unfired pressure vessels which are fabricated by welding are required by code to be stress relieved.

Many parts fabricated by arc welding are machined before going into the final assembly. If high residual stresses are locked up in the structure they may be released by the machining operation and harmful distortion will probably take place.

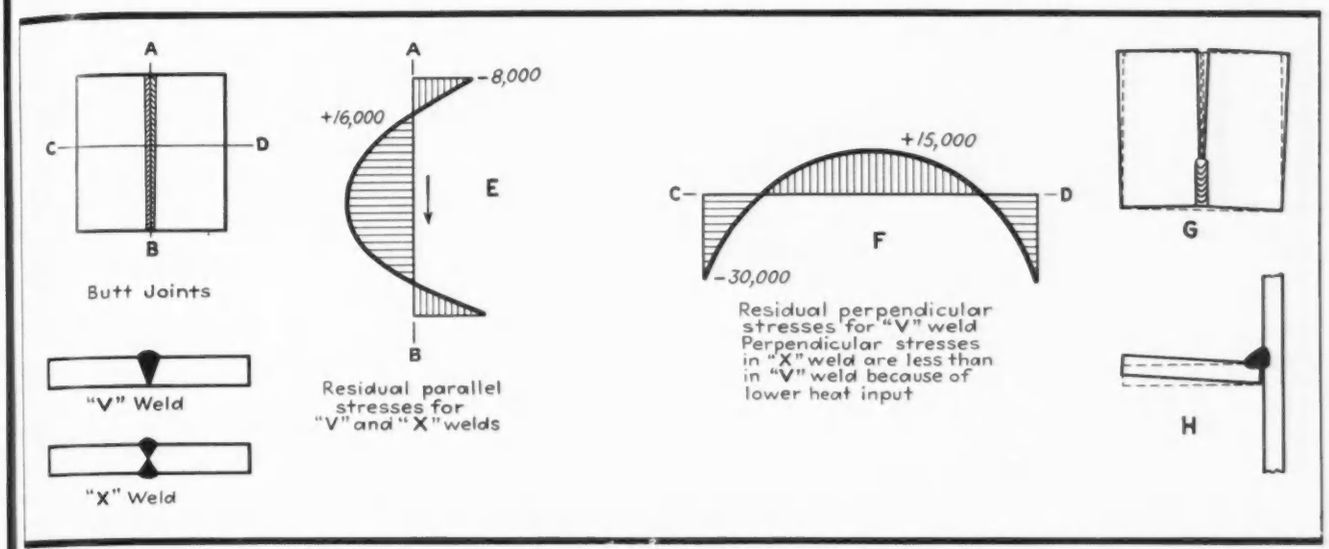
At times it is desirable to pre-stress the structure before welding so that the shrinkage stresses will be absorbed as the structure cools. Other times preheating with a torch before and during welding will allow plastic deformation to take place and accordingly relieve the stresses as they are formed.



Residual stresses will differ in direction with the welding procedure which is employed. In butt welds the stress will be greatest if the plates are prepared for a "V" type weld; slightly less for a "U" type weld; and considerably less for an "X" weld (double "V"). Stress diagrams are shown in *A* and *B* for a "V" and an "X" type weld. Stress diagrams courtesy of S. A. Eskilson.

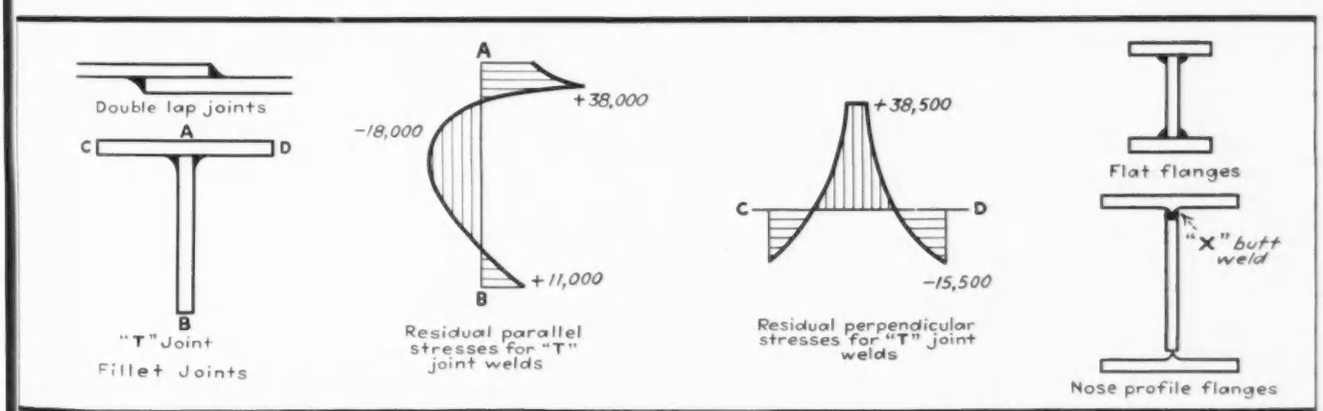
In general there is a pronounced tension stress at the surface of the plates and a compressive stress between the surfaces. The maximum parallel stress occurs at the center of the weld. As is to be expected the single "V" weld with its relatively larger amount of weld metal for a given thickness of plate results in a greater amount of residual stress perpendicular to the weld than if an "X" (double "V") type weld is employed.

Laying passes in the proper sequence in multiple pass welding has an influence on the stresses in the finished weld. The proper sequence to follow is shown in *C*, which results in lower stresses than if a single pass or weaving bead is used. Stresses parallel to the weld can be kept down 25 to 50 per cent less than with continuous welding by employing the welding method shown in *D*, ordinarily known as a back step sequence, however, the perpendicular stresses are considerably higher but preheating and peening will reduce stresses to 2/3 value.



Butt joints. Direction of residual stresses and also the average magnitude of the stresses in butt joints when employing different welding procedures are shown in *E* and *F*. The values were obtained from plates approximately ½ in. thick and while they are only averages, they are sufficiently accurate for design calculations. Stresses would be greater in thicker plates if only one bead or a weaving bead was used, however, multiple beads are recommended for welding plates over ½ in. thick and with the proper procedure the stresses would not exceed those given in the diagram.

Distortion caused by shrinkage stresses may be easily visualized by taking two plates and laying them down with their corners touching at one end and with a ¼-in. gap at the other end, after welding a short distance from the closed end the plates will pull together as shown in *G*, in which the dotted lines show original position of plates and solid lines indicate plates after welding at high speeds. This is even more noticeable with stainless steels because they are poor heat conductors. Another example is the welding of a vertical plate to a horizontal plate with a fillet weld as illustrated in *H*, in which dotted lines indicate position before welding and solid lines indicate position after welding. After finishing the bead the horizontal plate will bend decidedly toward the welded side.



Lap joints. Residual stresses in double fillet lap joints are in tension perpendicular to the weld and in compression parallel to the weld, there is little reliable information concerning the stresses in this type of joint. It is generally assumed that these joints welded under restraint have about half the perpendicular stresses which are set up in equivalent butt welds.

Tee joints. Usually if construction will permit fillet welds are made on both sides of the vertical plate. The stresses parallel to the weld are in tension while those in the adjacent parent metal are in compression. Residual stresses are of a lower order in the tee joint than those encountered in butt or even fillet welded lap joints.

Welded beams. Special beams and structural members are often fabricated by welding. The flanges are welded to the web with fillet welds and it has been determined that the residual stresses decrease as the flange width is increased. In welded beams the stresses in the welds are in tension. When beams are welded together end to end by an "X" type butt weld, high compression stresses are induced in the tension area of the web. In German bridge construction, special rolled flanges with a projection are used so that flanges are attached to the web with "X" type butt welds. This type of construction decreases the tension stresses in the welds by about 50 per cent. Strange as it may seem it has been found that there is no basic difference between the magnitude of residual stresses in rolled and welded beams over when the conventional flat flanges are used.

Welded cylindrical vessels. Tanks and pressure vessels of welded construction are now common. The magnitude of the residual stresses in welded cylindrical vessels will depend upon whether they are in the longitudinal or circumferential seams. In the circumferential welds the stresses perpendicular to the weld are about the same as those parallel to the weld, averaging about 16,500 lb. per sq. in. for ½-in. thick plate. However, in the longitudinal seams the stresses perpendicular to the weld will be low about 4,500 lb. per sq. in., whereas stresses will be about 32,000 lb. per sq. in. parallel to the weld.

STEEL CASTING

Analysis of design details in steel castings with a study of the various modes of joining sections. Illustrations courtesy of Steel Founders' Society of America

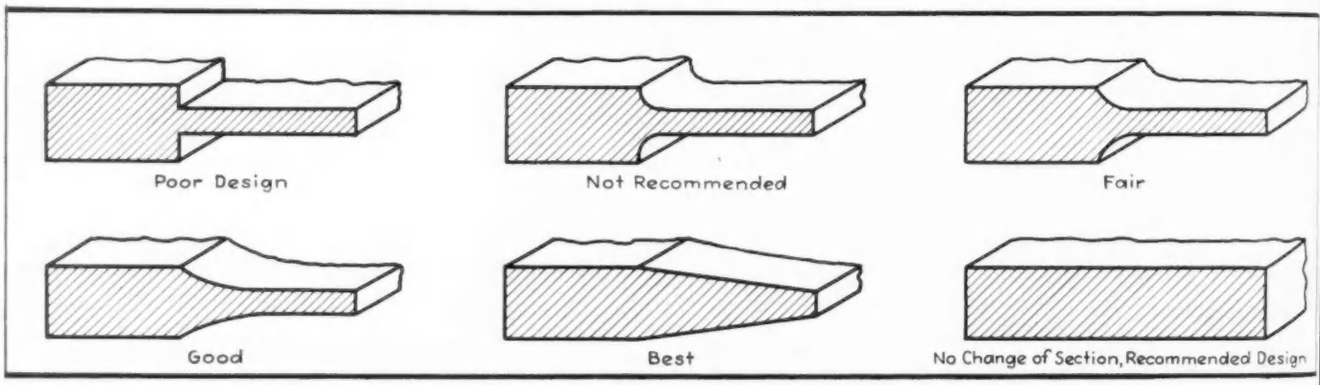
DESIGNERS when planning a design from which perfect castings may be produced, must consider internal stress and the behavior of the cast metal when contracting. Care in design must be taken to avoid large temperature differences that would produce hot tears at zones where excessive internal stresses might cause members to separate or crack at temperatures slightly below the steel's solidification temperature.

To avoid the formation of shrinkage cavities it must be possible to feed to all sections a sufficient amount of metal to make up for contraction at the time of casting solidification; that is, do not expect small sections to feed larger adjoining sections.

Two ways in which the designer may prevent the possibility of cracks or hot tear formation in a casting are; eliminating hot spots that are under stress, and eliminating the stresses that would act on the hot spots or other points of stress centralization.

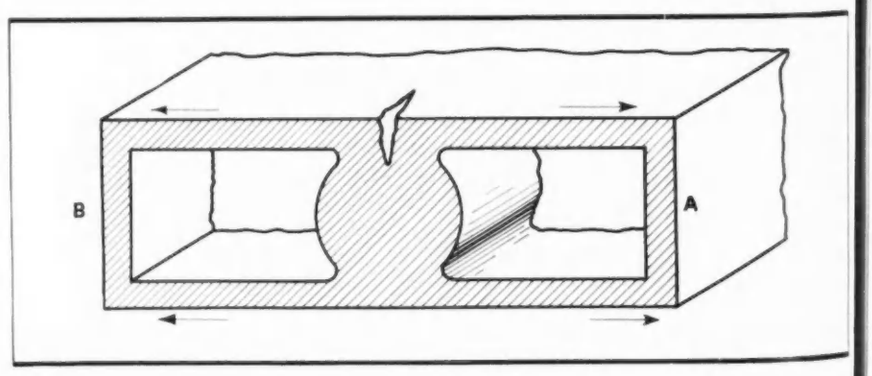
Hot spots are responsible for the setting up of temperature gradients, contraction variations, street formations and the resultant occurrence of hot tears. If in the design of a steel casting all sections have uniform thickness, the presence of hot spots will be reduced to a minimum.

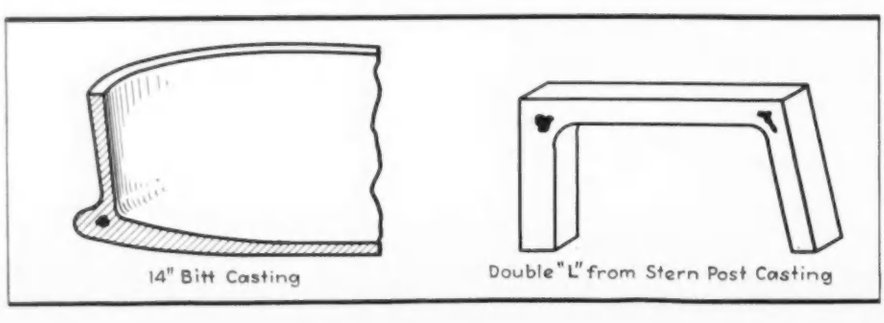
Material published by permission of the Navy Department, was first published in the May 1938 issue of the JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS. *Authors: C. W. Briggs, R. A. Gezelius and A. R. Donaldson.*



Sharp corners and abrupt changes in sections are zones where stresses acting upon castings usually concentrate. If, however, liberal fillets replace the sharp corner junctions the stresses will be more evenly distributed and hot tear formation will be less likely to take place. The relative merits of various designs to accomplish change of section thickness are indicated. They also suggest ways to reduce possibilities of hot tear formation to a minimum.

Hot spot and continuous wall section, two features of poor design, are illustrated in the cross-section. The continuous wall section would be responsible for stresses mainly in the direction of the arrows because of hindered contraction. If the cross end pieces *A* and *B* were eliminated the casting would not be under the major stresses as shown and failure would not be a possibility. A casting so designed could be assembled in the final form by welding previously cast or fabricated sections *A* and *B* into position.

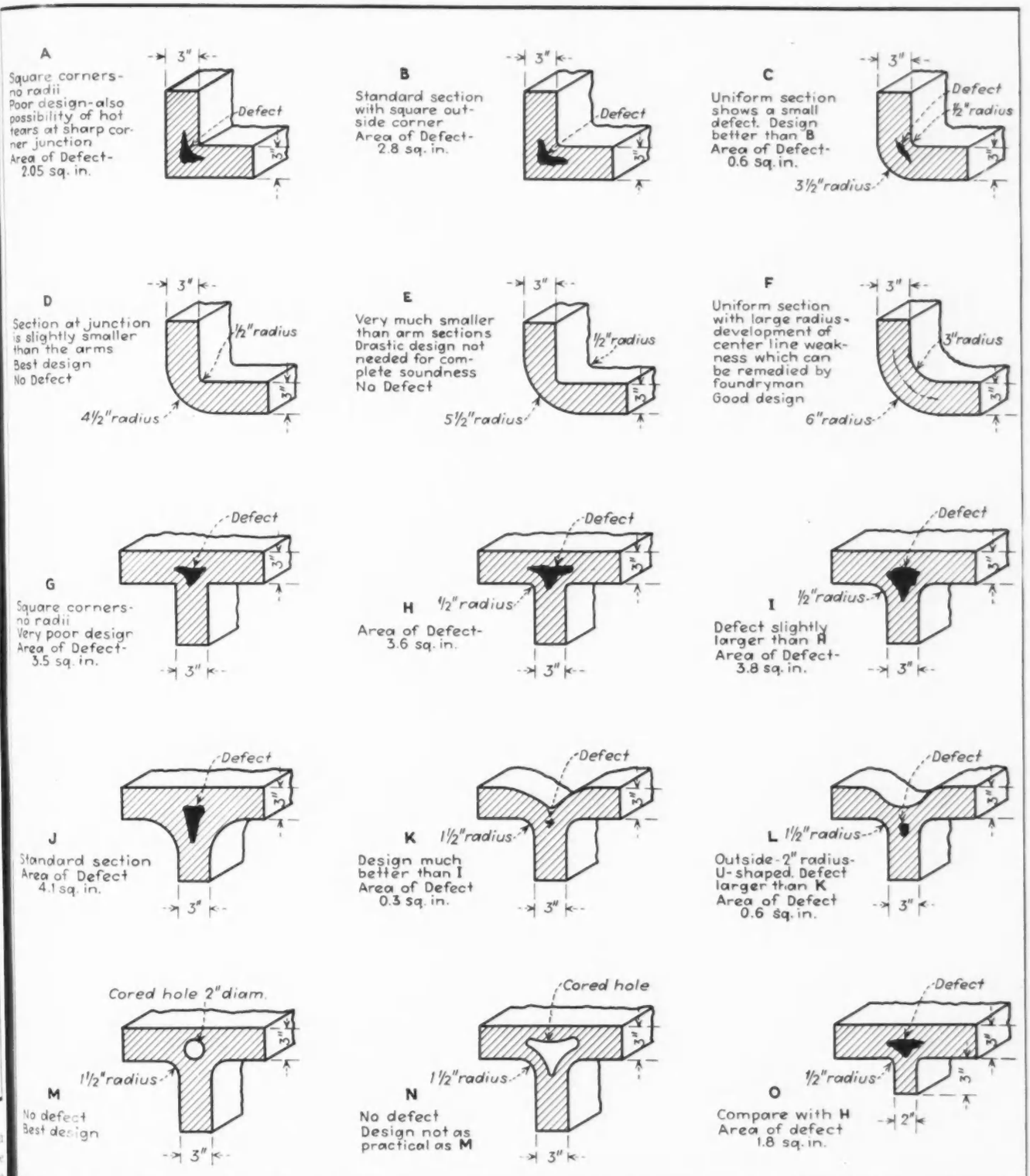




Bitt casting shown in section is an example of a poor design. Note the defect just inside of the fillet at flange and barrel connection, to remedy this condition a uniform section should be maintained or a hole should be cored out at position of defect.

Stern post casting shown is another example of poor design. To remedy the defects indicated the outside square corners should be rounded off.

DESIGN FEATURES



Ell and tee connections of various designs and their relative merits as indicated by studies on joined sections. The castings studied were cast from patterns which were 3x3 in. in cross-section, the arms were about 2 ft. long and headed at the extreme end. They were poured through feed heads on the arms. In order that no variations should be overlooked during pouring, studies were made by pouring through one arm, and through two arms at the same time. Molding was according to the dry sand practice and plain carbon basic electric steel was used, poured from a teapot ladle. The sections were all poured in the horizontal position. The points illustrated will be of comparable order in sections other than those of 3 in. and the information obtained can be used in the design of other sections.

Question and Comment

Torsion Spring Design Charts

VICTOR TATARINOFF

Torsion springs made from round steel might be utilized as shock absorbers in hand-operated milk separator-starting devices, for revolving office chairs, or in power registering apparatus. The spring material is subjected to bending stress only. For motor spring design see *Product Engineering*, December 1938. The principal notations used in developing the following formulas are:

M—maximum torque in in. lb.; K—factor of structural safety, selected from the table I.;

T—ultimate tensile strength of spring material in lb. per sq. in. selected from the curves in Fig. 1.;

d—diameter of spring wire in in.; l = theoretical length of spring wire in in.;

D_o—inside diameter of spring coils in in. (see sketch in Fig. 2);

θ—angle of spring working deflection in deg.;

n—number of coils in helical spring when free;

E—modulus of elasticity of spring material, assumed 28.5×10^6 lb. per sq. in. for steel;

h—height of spring in in.;

y—clearance between coils depending on difference of final and initial number of spring coils, in in.; for minimum value select $y = \frac{1}{64}$ in.

The fundamental equations for helical springs coiled from round material are:

$$KM = \frac{\pi d^3}{32} T; \qquad \frac{M}{\theta} = \frac{\pi E d^4}{57.3 \times 64 l};$$

$$l = \pi (D_0 + d) n; \qquad h = (d + y) n$$

The same equations are used for spiral spring design, but for value of l select:

$$l = \pi d (N + n_0)^2 + (N + n_0) \quad (c + 1),$$

in which N is the number of revolutions of the shaft; n_o—number of turns in the spring when free, ranging from 3 to 5; C—ratio of diameter of shaft D_o to diameter of spring wire, thus

$$C = \frac{D_0}{d}$$

For determining the outside diameter of the spring when free, D, we use:

$$(cb - 1) n_0 - n_0^2 = (N + n_0)^2 + (N + n_0)$$

$$(C + 1) \text{ in which } b = \frac{D}{D_0}$$

The calculation involved in the design of torsion springs can, however, be facilitated by the use of the accompanying graphs based on the above equations and constructed for two principal materials, namely: cold drawn standard steel wire A and standard silico-manganese steel B (see chart, Fig. 2). Using reasonable values of the safety factor K given in table I, the charts can also be utilized for other materials.

The procedure to be adopted in design calculations for springs made from round material will be explained by typical numerical examples.

Example 1. A shock absorber torsion spring fitted to hand-operated milk separator. The initial maximum torque $M = 450$ in. lb. The spring may be made from standard silico-manganese steel wire (material B) and the following restrictions must be observed: the angle of spring working deflection $\theta = 15$ deg., the inside diameter of the spring $D_o = 1\frac{1}{2}$ in. Selected from table I, $K = 3$; $km = 1{,}350$ in. lb. Using the graph in Fig. 2, trace horizontally from the point on the left-hand vertical scale $km = 1{,}350$ to the sloping line B. The intersection thus obtained will indicate on the top scale a nearest standard size of spring wire $d = 0.394$ in. and on the bottom scale a corresponding Washburn & Moen gage 4–0. Then trace horizontally from the point on the left-hand vertical scale $\frac{M}{\theta} \times 100 = \frac{45{,}000}{15} = 3{,}000$ to the vertical line drawn up from the point on the bottom scale 4–0. The intersection of both lines will indicate a sloping line corresponding to: $(D_o + d)\ n = 6.2$. Thus number of spring coils: $n = \frac{6.2}{1.5 + 0.392} = 3\frac{1}{4}$. Length of spring wire without end attachments $l = \pi \times (D_o + d)\ n = 3.14 \times 6.2 = 19\frac{1}{2}$ in. Height of spring $h = (0.394 + \frac{1}{64}) \times 3.25 = 1\frac{13}{32}$ in.

(To be concluded in June number P.E.)

TABLE I. FACTORS OF STRUCTURAL SAFETY K

Nature of spring duty	*Cold drawn steel wire*		*Heat treated steels, quenched*		
	Standard 0.55 carbon steel wires A	*Commercial wires C*	*Standard silico-mang. steel wires B*	*Standard 0.55 carbon steel wires D*	*Commercial hot-rolled bars E*
Limited service; springs under dead load (doors, revolving chairs, etc)	2.5	3	...	2.5	3
Limited service, failure serious (shock absorbers, starting gears, etc.)	3	3.5	3	3	3.5
Limited service, failure serious; permanency and accuracy of spring deflection are required (revolving drums of indicators, etc.)	3.5	...	...	...	...
Durable responsible work; live non-alternating loads (back stroke gears of tools, etc.)	4	...	4	4.5	...

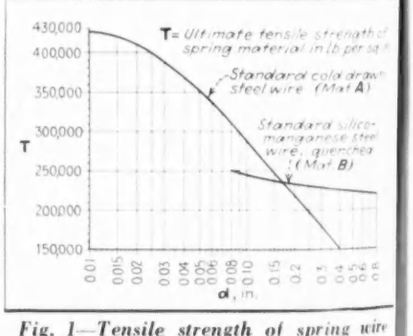


Fig. 1—Tensile strength of spring wire

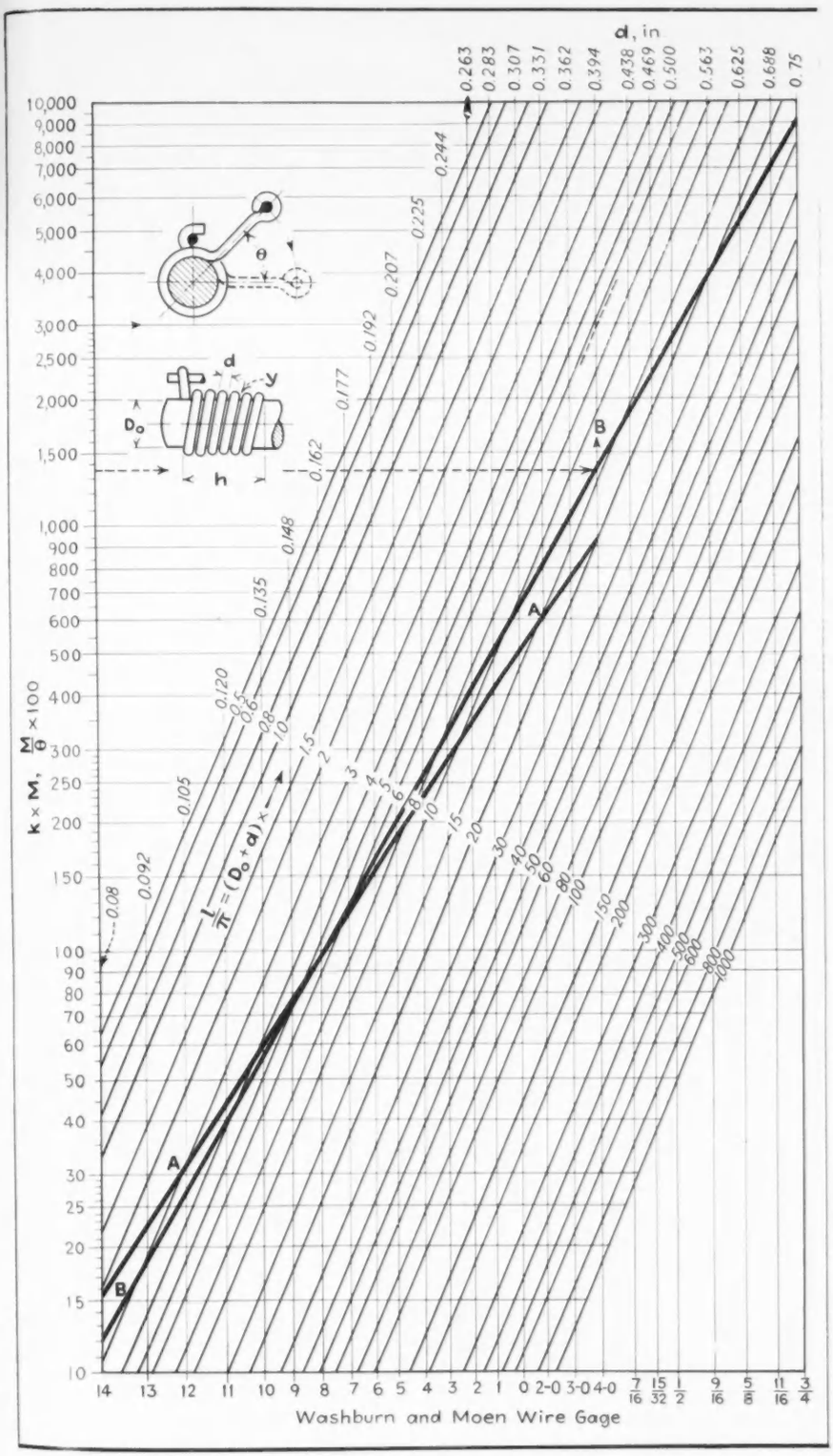


Fig. 2—Design chart for cold drawn and silico-manganese torsion springs

Computing Magnetic Pull Graphically

To the Editor:

Your contributor Graham Lee Moses in his article on magnet coils in March *P.E.*, page 129, shows in Fig. 2 a family of curves. These are for the graphical computation of the (very approximate) formula for the magnetic pull:

$$AT = 2660\, L\sqrt{P}$$

In this, P stands for F/a, the pull in lb. per sq. in. of one pole face. Because he took AT and P for his variables, there resulted the family of parabolic curves. These cause not only needless time and trouble in plotting, but have a low accuracy, especially, for interpolation. Had he taken instead AT and L for the co-ordinate variables, the family of curves would be simply radial straight lines.

For, let $x = m_1\, AT$ and $y = m_2\, L$ or $L = y/m_2$

Substituting, we have

$$x = 0.266\, P\, y\, m_1/m_2$$

m_1 and m_2 are the length in in. of the unit along the x and y scales, respectively, and one inch equals the length, say, of two of the squares in his figure. Then $m_1 = 1/1000$ and $m_2 = 10$ respectively. Substituting we have, $x = AT/1000$ and $y = 10L$. These are the scale equations for the scales below and to the left respectively. Also substituting further, $x = 0.266\, P\, y$. This is the equation for each radial for a single value of P. Thus for $P = 1$, $x = 0.266y$; $P = 4$, $x = 0.532y$; and $P = 9$, $x = 0.798y$. These being the equations of three of the P radials, which can be readily plotted on the squared diagram.

—Carl P. Nachod
Nachod & U. S. Signal Company

That Block Problem

To the Editor:

Let α be the angle and v the velocity at which the block leaves the sphere. Let θ be any angle less than α and s the velocity at this angle. Because of the velocity s the block has a centrifugal acceleration f, as follows:

$$f = \frac{s^2}{R} \qquad (1)$$

The block will leave the sphere when the value of f is equal to the component of g acting towards the center of the sphere. This is at the angle α, hence

$$f = \frac{v^2}{R} = g\cos\alpha \quad \text{or} \qquad (2)$$

$$v^2 = Rg\cos\alpha \qquad (3)$$

The average acceleration acting on the block during the angle α can be obtained as follows. The acceleration at angle θ is

$$a = g\sin\theta \qquad (4)$$

On plotting this acceleration against the angle θ and determining the area under the curve between the interval from 0 to α and dividing by α the average acceleration a_{av} is obtained.

$$a_{av} = \frac{\int_0^\alpha g\sin\theta\, d\,\theta}{\alpha} = \frac{\left[-g\cos\theta\right]_0^\alpha}{\alpha} = \frac{g - g\cos\alpha}{\alpha} \qquad (5)$$

During the angle α the block travels a distance D which is equal to $R\alpha$. But

$$D = \frac{1}{2}\, a_{av}\, t^2 \text{ and} \qquad (6)$$

$$v = a_{av}\, t \qquad (7)$$

substituting for t^2 in (6)

$$D = \frac{v^2}{2\,a_{av}} = R\alpha \qquad (8)$$

from which

$$v^2 = 2\,R\alpha\,a_{av} \qquad (9)$$

equating this equal to (3)

$$2\,R\alpha\,a_{av} = R\,g\cos\alpha \text{ or} \qquad (10)$$

on substituting for a_{av}

$$2\,\alpha\,g\left(\frac{1-\cos\alpha}{\alpha}\right) = g\cos\alpha \qquad (11)$$

hence

$$2 - 2\cos\alpha = \cos\alpha \qquad (12)$$

and, $\cos\alpha = \frac{2}{3}$ and $\alpha = 48$ deg. 11 min. 25 sec.

The values for a and y then are

$a = 2\sin\alpha = 1.491$ ft.

$y = 2 + 2\cos\alpha = 3.333$ ft.

The velocity with which the block leaves the sphere is

$$v = \sqrt{2 \times 32.2 \times \frac{2}{3}} = 6.55 \text{ ft./sec.}$$

The horizontal component and vertical component of this velocity then are

$v_h = 6.55\cos\alpha = 4.367$ ft./sec.

$v_v = 6.55\sin\alpha = 4.513$ ft./sec.

The problem is now simply one of a freely falling body with an initial horizontal and vertical velocity dropping through a distance y. The curve of this path is parabola.—EDGAR H. SCHMIDT.
American Type Founders, Inc.

[*Editor's Note*—Additional solutions to the block sliding problem were submitted by W. H. Church, *Norwalk, Conn.*, Jerome Calcagnetti, *Easton, Pa.*, F. V. Tarbell, *Erie, Pa.*, John I. Nugent, *Rochester, N. Y.*, F. M. Tousley, *Detroit, Mich.*, Harvey S. Pardee, *Ravinia, Ill.*, G. C. Morris, *Evansville, Ind.*, William W. Johnson, *Cleveland, Ohio*. Since it is manifestly impossible to print every solution received, the editors take this opportunity of thanking these readers for their efforts.]

Raising the Modulus of Cast Iron

To the Editor:

Concerning the letter, December *P.E.*, page 491, from Mr. E. W. Clem, the accompanying table taken from the joint symposium on cast iron by the *A.S.T.M.* and the *A.F.A.* in 1933 illustrates the variation in modulus of elasticity with tensile strength. It must of course be remembered that considerable variation can occur as between two different cast irons, but as the minimum and maximum show, this is not usually enough to counteract the effect of increasing tensile strength. These tests were on transverse specimens, 1.20 in. diameter and 18 in. span,

Tensile Strength Lb. Per Sq. In.	Number of Tests	Modulus of Elasticity Average, Lb. Per Sq. In.	Modulus of Elasticity Lb. Per Sq. In. Minimum	Maximum
15,100 to 20,000	4	11,600,000	10,400,000	12,800,000
20,100 to 25,000	4	14,200,000	13,300,000	14,600,000
25,100 to 30,000	2	14,500,000	14,300,000	14,600,000
30,100 to 35,000	7	16,000,000	13,200,000	17,400,000
35,100 to 40,000	3	18,100,000	16,500,000	19,900,000
40,100 to 45,000	2	18,500,000	17,900,000	19,100,000
45,100 to 50,000	1	22,600,000		
50,100 to 55,000	1	19,100,000		
55,100 to 60,000		19,900,000		

and each set represents the average of at least three bars. Tests were also run in tension and compression, and the average modulus for these tests at 25 per cent of the ultimate load is 90 per cent of that of the transverse with very little variation. For the original data on this, I refer Mr. Clem to the *Proceedings of the American Society for Testing Materials*, Vol. 33, Part I, p. 87 et seq., 1933. —JAMES T. MACKENZIE
Chief Metallurgist
American Cast Iron Pipe Company

To the Editor:

The data which Mr. MacKenzie lists is very interesting. However, there is quite a difference between this information and that which we have been obtaining. Recently, we made twelve tests on three different mixes of cast iron, and find that in no case did the modulus run over 16,400,000; it did run as low as 9,300,000. —E. W. CLEM
Chief Engineer
Rice, Barton & Fales

Govern Peripheral Speed Mechanically?

To the Editor:

Is there a method of governing the peripheral speed of a spool by mechanical means? My problem is one where it is necessary to wind a tape on a spool at a certain number of feet per minute.

I have solved the problem by driving the tape through friction rolls and then winding it on a spool driven by a slip clutch but I would like to eliminate the necessity of using drive rolls if possible.
—ROBERT R. KINSLEY
Philadelphia, Pa.

[*Editor's Note*—See *Product Engineering*, April, 1939, page 172-174.]

Drill for Plastics

To the Editor:

Can you give me any information in regard to the best drill, diamond or other type, for drilling plastics in fast production work? —GEO. M. THOMAS
Philadelphia, Pa.

Can You Work This One?

H. E. SMITH

Solution to March problem—

Forward March!

On St. Patrick's Day the Irishmen were marching ten abreast and that fellow in the last row disappeared after a short beer. The Grand Marshal was unsuccessful in reorganizing things, since in every case the last row was always one man short. Eleven abreast would not do. The least common multiple of the numbers 2 through 10 is 2,520; but while 2,519 leaves the last row just one man short with any number from 2 to 10 abreast, it is divisible by 11 and therefore does not fit the conditions of the problem. Therefore, there must have been at least 5,040 Irishmen in the parade before one got thirsty.

This month's problem—

Canny Measurement

A milkman, or better, a milkmaid had a 14-quart can full of milk, and also an empty 5-quart and an empty 9-quart measure. The poor girl had to divide the milk into two equal amounts. Assuming no losses in transfer, how did she do it, using only the three containers, 14, 9 and 5 quarts, respectively?

News

Copper Temperature Proposed as Criterion for Transformer Loading

A.I.E.E. hears practical method which permits safe overloading by disconnecting load according to temperature rather than current

AT THE RECENT winter convention of the A.I.E.E. Westinghouse engineers H. V. Putnam and W. M. Dann pointed out that if a transformer is allowed to carry an overload until the actual copper in the winding becomes excessively hot, the amount of that overload will be surprisingly large, especially if the overload does not last too long. The practical method of utilizing this principle provides for tripping a relay that disconnects the load according to copper temperature rather than current.

According to the paper, copper temperature—not current—is the proper criterion for determining the safe overload, since "maximum safe current" is a somewhat mythical value. A very large current might be safe for a time, if the transformer had started out cold; but a much smaller current might be dangerous if the transformer had been struggling along for some time with a relatively high overload. But a temperature-sensitive device cannot be placed right on the winding, because the winding is operated at high voltage and cannot be touched: neither can any wire coming from it. The device must respond faithfully to the copper temperature in the winding without actually being in contact with it. This can be done easily by means of an ordinary bimetallic strip, which is immersed in the same oil as the winding, and which carries a current equal to, or proportional to the current in the winding. An extreme movement of the bimetal, corresponding to an excessive copper temperature, releases a mechanical latch that trips circuit breaker and disconnects load.

This method of operation has been applied to transformers ranging in size from small distribution units to substation transformers feeding an entire system. On a typical test, a 5-kva. distribution transformer carried 3½ times normal full load for one hour before tripping, and at the tripping point the copper had attained a temperature of 145 deg. C. A copper temperature of 145 deg. C. seems too high to be safe, but this overload has been repeated over 700 times without apparent damage to the transformer or the temperature relay.

The feasibility of the method, however, depends upon a determination of the life of transformer insulation at the proposed higher operating temperatures. Dr. Charles F. Hill, Westinghouse research engineer, recently completed tests on cellulose and oil, the two most common transformer insulating materials, at temperatures as high as 140 deg. C. Results of the tests, some of which required more than two years, were presented before the convention.

New Studebaker Enters Economy Car Market

After three years of market research, engineering development and preparation for production, Studebaker announced the Champion—a new low-priced car to compete with the "Big three" for the automobile buyers' dollars.

At the preview of this new automobile held recently in New York City, Studebaker President Paul G. Hoffman explained in detail the successive steps in the creation of the new economy car. It started with an extensive survey of the automobile market, the buyers' habits and preferences. Nothing startling was revealed by this survey—the American public wants a large, roomy, low-priced car with all the comfort and operating conveniences of the medium-priced models, plus the utmost in operating economy and modern appearance.

With the "sales-appeals" factors thus determined, Studebaker engineers were set to the task of developing from a "clean sheet of paper" a car to meet the buyers' specifications.

According to Mr. Hoffman, because the engineer would be able to design without the restriction of requiring parts to be interchangeable with other models, it was expected that they would be able to achieve economies not attainable in the designs of the "Big Three". By the same token, it was expected that a superior design from the marketing point of view could be created. Thus Studebaker used the handicaps of the "Big Three" to his own advantage.

Outstanding design features of the Champion are new light-weight six-cylinder L-head 78 brake horsepower engine, built entirely in the Studebaker factory . . . rigid weight-saving welded frame made possible by the latest developments in metallurgy and chassis design . . . roomy, conservative-modern body styled by Raymond Loewy, using completely new body-finishing production methods . . . improved "Planar" spring suspension with liberal use of rubber mountings to give smooth riding qualities . . . hydraulic brakes . . . Warner three-speed synchromesh transmission with shift under the steering wheel.

Contrary to the trend followed during

A Champion makes a 68 ft. broad jump—and the new Studebaker low-priced car drives away unharmed in a recent test made before Hollywood cameras

the past few years by other low-priced cars, roominess, comfortable riding qualities and safety have been achieved without resorting to the addition of weight. Studebaker engineers claim 20–30 per cent increase in operating economy, made possible through the substantial weight reductions in the new engine and chassis which brings the shipping weight of the car down to 2,375 lb., several hundred lb. lighter than its nearest competitor in the low-priced automobile class.

The veteran independent automobile manufacturer, in bringing out the new economy car, spent $3,500,000 in new tools and equipment to take advantage of the cost savings available through the use of up-to-the-minute engineering methods. Complete details of the engineering behind the Studebaker Champion will be given in an article which will appear in a later issue of *Product Engineering*.

Navy Bureau Seeks Nonflammable Dope

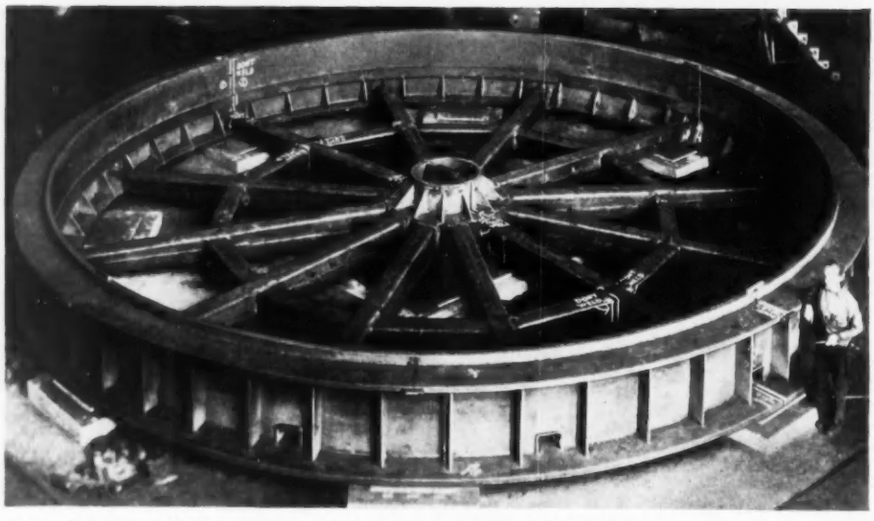
CELLULOSE nitrate "doped" fabric, which is used at present to meet the need for light and inexpensive covering for the wings and fuselages of small airplanes, has undesirable properties in that it is easily ignited and burns rapidly. At the request of the Bureau of Aeronautics of the Navy Department, the Bureau of Standards is now working to develop a nonflammable dope which would compare favorably with or surpass the cellulose nitrate dope.

The four variables involved in the formulation of airplane dopes are the type of plastic, plasticizer, solvent, and diluent. It has been shown that the solvents and diluents in a dope govern to a large extent its tautening properties and the durability of the films deposited on the fabric. A report by F. W. Reinhart and G. M. Kline of the organic plastics section presents the results of an investigation of the effect of these four variables upon the properties of films formed from various plastics, twelve of which were examined.

Data are included on the solubility of these plastics in common organic solvents and mixtures of solvents and diluents, their compatibility with various plasticizers, and the degree of flexibility, clarity, and shrinkage of the films prepared from the plasticized and non-plasticized compositions.

On the basis of the information obtained with the single solvents and solvent-diluent combinations, various mixtures were formulated in an endeavor to obtain flexible, clear films characterized by marked shrinkage, qualities which are of prime importance in a good airplane dope. This process of selective formulation and testing was continued for each material until no further improvement in the desired film properties was noted.

The solutions chosen in this manner, with the addition of selected plasticizers, have been applied to fabric-covered test panels to determine their tautening properties and the weathering characteristics of the deposited film. Exposure and flammability tests on these experimental panels are now under way. An account of this work is given in the March issue of the *Technical News Bulletin* of the National Bureau of Standards.



Huge 46-ton welded pot-chuck, designed with high rigidity for slotting large teeth for the gears of 16 in. naval gun turrets, constructed in two halves by Lukens Steel Company at Coatesville, Pa., and shipped to Camden, N. J., to be assembled and finished. Over 33½ ft. in diameter, the chuck stands 3½ ft. high. Inner and outer circles and web are of 2½ in. steel plate. In shipping by well-bottom flat car, the bottom of the mammoth sections rested 3 in. above the track, and only 1 in. overhead clearance was allowed for certain spots on the route

MEETINGS

AMERICAN FOUNDRYMEN'S ASSOCIATION—*Annual convention, Cincinnati, Ohio, May 15–18. C. E. Hoyt, executive vice-president, 222 West Adams St., Chicago, Ill.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*World Automotive Engineering Congress, Hotel Pennsylvania, N. Y., May 22–28, Hotel Statler, Detroit, May 31–June 8, Hotel Fairmont, San Francisco, Cal., June 6–8. John A. C. Warner, secretary, 29 W. 39th St., N. Y.*

AMERICAN IRON AND STEEL INSTITUTE—*General meeting, Hotel Waldorf-Astoria, N. Y., May 25. Walter S. Tower, executive secretary, 350 Fifth Ave., N. Y.*

ASSOCIATED MACHINE TOOL DEALERS OF AMERICA—*Spring convention, Van Curler Hotel, Schenectady, N. Y., June 5–6. Thomas A. Fernley, Jr., executive secretary, 505 Arch St., Philadelphia, Pa.*

S.A.E. World Congress to Tour Four Cities

During the SAE World Automotive Engineering Congress, May 22 to June 8, foremost authorities in automotive engineering and related sciences from the leading nations of the world will convene in New York, Indianapolis, Detroit, and San Francisco. Sixty technical sessions will be combined with tours of the nation's giant automotive plants, attendance at America's greatest automobile race, sight-seeing trips of engineering and general interest, and visits to World's Fairs in New York and San Francisco. SAE Sections in the four key cities of the Congress will act as hosts. Every activity of the society is represented in the sessions scheduled.

SAE activities which will sponsor sessions during the five-day technical meeting in New York, May 22-26, are: Aircraft; Aircraft Engine; Fuels & Lubricants; Passenger Car; Passenger-Car Body; Transportation & Maintenance; Truck, Bus, & Railcar; Diesel Engine; Tractor & Industrial Power Equipment.

While no technical session is scheduled during the Congress visit to Indianapolis, May 29-30, interest will concentrate on the mechanism of the cars which will participate in the 500-mile International Sweepstakes.

In Detroit, May 31-June 2, delegates will attend a session arranged by Production Activity, as well as visit some of the huge automobile plants.

During the final days of the Congress in San Francisco, June 6-8, technical sessions will be under the auspices of the SAE Aircraft, Transportation & Maintenance, Fuels & Lubricants, and Diesel Engine Activities.

Tool Engineers Hold Successful Show

THE 2nd Machine and Tool Progress Exhibition of the American Society of Tool Engineers closed its doors until 1941 with new records established in attendance, number of exhibitors, size of show, and business done by exhibitors.

The show ran from Tuesday, March 14, to Saturday, March 18, at Detroit, Mich. On Monday afternoon preceding the opening, a special preview was followed by a dinner at which the Society's fact finding committee on "The Relationship of Machines to Employment and Standard of Living" presented its preliminary report. Highlight of the report was that machine tools create employment rather than unemployment, but that temporary displacement of workers is sometimes caused by the introduction of machine tools. The report recommended that industry study this problem and develop means of shortening the period of unemployment by aiding displaced workers to find new occupations or training them for such new occupations.

Coincident with the Machine and Tool Progress Exhibition the A.S.T.E. held its annual convention featured by two technical sessions which covered phases of accurate surface finishing and recent developments in manufacturing methods and equipment.

Do You Know That—

NEW TIRE CHAINS have borium studs nearly as hard as diamonds. (8)

A PENETRATING DYE for application on concrete floors is now being offered in four colors. (9)

A NEW PHOTOFLASH lamp is so small that 18 may be carried in a coat pocket. The flash is timed so that cameras synchronized for older bulbs need not be reset. (10)

A TURBOGENERATOR SHAFT 25 ft. long may elongate a quarter of an inch at operating temperature. (11)

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.)*

No. 11

QUESTION: Is it patentable invention to adapt machinery which is well known in one industry to accomplish a new or improved result in another industry?

ANSWER: The most common test used to decide this question is whether a person of ordinary skill in one industry could be expected to know the methods used in other industries. But it is very difficult to determine just what the mental equipment of any worker can be expected to be, and how much knowledge he might reasonably be expected to have of analogous industries.

To use an ordinary pump, such as is used in pumping water, to pump other fluids would be so obvious as not to constitute patentable invention. But how about air conditioning? It was first used to maintain constant conditions of humidity in textile mills. Later it was adapted to use in candy factories in which constant humidity and temperature are equally important. It has also been taken over in restaurants, theaters and other buildings, not for manufacturing reasons, but to increase the comfort of human beings.

Were these analogous uses patentable invention? One school of thought says "no"—that it is all part of the broad art of air conditioning. Their opponents make a good case for themselves, however, on the ground that the results achieved by the use of old equipment for new purposes were so useful and even unexpected that they indicated true invention.

The best test seems to be whether the new use of the old equipment has made revolutionary, useful changes in the analogous industry. If the difference is only in kind due to the difference between the industries, there is no patentable invention. But if it results in a considerable, practical, new and useful result that is beyond any similar result achieved in the industry it is invention.

Of course certain industries are so similar that one can be considered merely a branch or an outgrowth of the other. In that event, knowledge of the methods used in the allied industries might reasonably be expected of any skilled worker in any of them. But where there is a material difference between the industries—where they are not commonly associated—there is usually at least the presumption of invention.

Most workers are so deeply engrossed in their own work that they have no time to study the methods of dissimilar industries. When one of them does, and finds in another industry a solution to his own problems, he can reasonably be credited with using the research imagination and and exercise of the inventive quality which makes of him not merely a mechanic but an inventor. Usually to find a use in one industry for equipment used in another is invention, always bearing in mind the qualifications of this rule which I have already cited.

Here are three court opinions on the question which have been used as precedents.

One of them reads, in part: ". . . if the new use be so nearly analogous to the former one that the applicability of the device would occur to a person of ordinary mechanical skill, it is only a case of double use, but if the relations between them be remote, and especially if the use of the old device produce a new result, it *may* at least involve an exercise of the inventive faculty."

Again: ". . . Indeed, this use of the connecting mechanism can hardly be termed analogous to such as similar mechanisms had previously been used for; but even if it were, the results are so important, and the ingenuity displayed to bring them about is such as we are not disposed to deny the patentees the merit of invention."

On the other hand, consider this decision of the Supreme Court of the United States which lays down quite definitely the rule when use for analogous purposes is not patentable invention:

"It is settled by many decisions of this court . . . that the application of an old process or machine to a similar or analogous subject, with no change in the manner of application, and no result substantially distinct in its nature, will not sustain a patent, even if the new form of result has not before been contemplated."

In short, this subject is so complex that before going ahead with designs which involve the use of old machines for analogous purposes it would be wise to consult your patent attorney who, after study of your peculiar problem, should be able to guide you along the right path.

New Materials and Parts

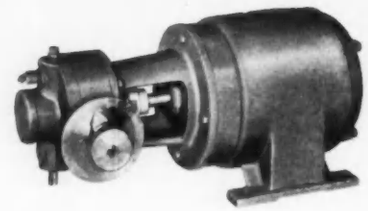
Corrosion-Resistant Bearings

Ball and roller bearings made of K-monel in all required sizes and types for services involving exposure to many corrosive liquids and gases. This nickel-copper alloy can be heat-treated to provide a hardness, wear-resistance and strength not ordinarily associated with non-ferrous bearing materials. Its resistance to corrosion is such that it can withstand the action of many acids, most alkalis and a wide range of gases. It retains high mechanical properties over a range from low subzero temperatures

to above 800 deg. F. It is non-magnetic down to −110 deg. F. Typical uses for these bearings include food handling equipment and in chemical plants. Bantam Bearings Corp., South Bend, Ind.

Hydraulic Pump

A small variable volume hydraulic pump which provides for accuracy of control to a minimum of 5 cu. in. per min. A special feature incorporated in the pump is a rapid traverse or quick take-up, which will allow the pump to deliver its maximum volume when it is not working against the load or is working only against a light predetermined load. This same control can be arranged to serve as an overload feature which will move the pump to no stroke, maintaining pressure, but not delivering volume. Pump is of the three-piston type, the three-piston cylinder body and rotary valve being combined in a single shaft. Pump is good for continuous



operation at 1,000 lb. per sq. in., and for intermittent operation at 2,000 lb. per sq. in. While it is usually furnished integral with motor, it can be furnished with foot mountings where required. It is also built in two volume capacities, 100 cu. in. and 175 cu. in. in maximum capacities in the same body size (approximately $9\frac{1}{2}$ x 21 x $9\frac{3}{8}$ in. in size and 100 lb. in weight). Denison Engineering Co., 236 N. Water St., Columbus, Ohio.

Heater Motor

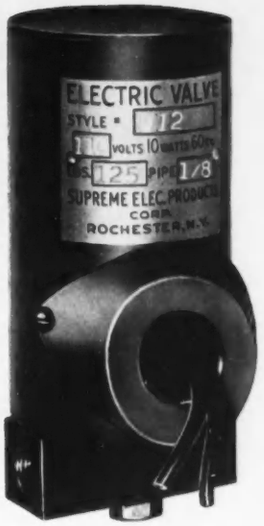
A new a.c.-d.c. 1/10th hp. motor, especially designed for bus heating and ventilating systems. Ball bearings or self-aligning sleeve type bearings are obtainable. The ball bearings are packed with a special heat-resisting grease and the sleeve type bearings are lubricated by felt-packed oil reservoirs. Motor operation is said to be satisfactory over a wide range of voltages and frequencies. Mountings can be furnished for cradle, base or flange applications. Motor is available in both 6 and 12 volts d.c. and also in 115 volts a.c.-d.c. Standard finish is black with chromium trim, but special finishes are available. Delco Appliance Div., General Motors, Rochester, N. Y.

White Edger for Tracings

For applying a special binding tape to protect the edges of tracings and drawings. Using a special binding tape manufactured by the Minnesota Mining & Manufacturing Company this machine applies it simply and easily to the edges of tracings, drawings, shop prints and other paper records which require a lot of handling. Binding tape has exact amount of adhesive on it to make a permanent and lasting edge which will not curl or peel off. Heat from the blueprint machine will not affect the tape and many edged sheets can be filed together without sticking together. David White Co., Inc., 315 W. Court St., Milwaukee, Wis.

Colloidal Graphite

A new form of "dag" colloidal graphite which makes possible completely opaque plastics. The graphite is said to have such infinitesimal particle size that it will readily stay in suspension in many low viscosity, volatile fluids miscible with plastics. According to the manufacturer, further uses of the new product in the plastic field may also lie in the direction of providing dry lubrication where, for various reasons, oil should not be used. The product presents an advantage in that it readily adheres to the surface of materials, forming a dry lubricant film integral with the surface of the material itself. Colloidal graphite may be applied by spraying, brushing, or dipping, using volatile-liquid carriers which leave a graphite film after evaporation of the liquid carrier. Acheson Colloids Corp., Port Huron, Mich.

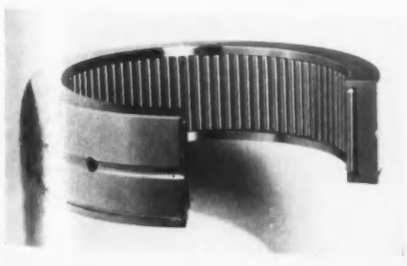


Solenoid Valve

An improved Type H solenoid valve for control of water, air, gas, oil or steam, which has a novel scheme for electrical connections. The lower section of the coil housing is empty and provides a terminal chamber into which the wires are pushed after making the electrical connections. An adapter receives a straight or angle BX connector or conduit lock-nut. For cord connections, a porcelain bushing is inserted in the adapter. A "composition tip" in the impulse plunger and a similar stop at the upper end of the plunger travel silence the usual click when valve opens or closes. A plug, containing the seat, is easily removable for cleaning without disturbing the electrical or pipe connections. Pipe sizes $\frac{1}{8}$, $\frac{1}{4}$ or $\frac{3}{8}$ in. with 1/16 and $\frac{1}{8}$ in. diam. orifice. Supreme Electric Products Corp., Rochester, N. Y.

Needle Bearings

One-piece outer race construction is the keynote of the new "Cyclops" needle bearing. An ingenious method of retaining a full complement of rolling elements without the aid of any auxiliary parts, yet permitting ready disassembly, has been developed. The ends of the rollers are conispherical, forming ball point contact with the race lands while in their path of travel. Cyclops bearings are provided with an oil groove and a snap ring channel which reduce to a minimum the cost of machining a recess for lubrication and locating of the bearing in the housing. Available in a range for shaft diameters from $\frac{1}{2}$ to 8 in., with and without inner races. Bulletin SF-16 available. Roller Bearing Company of America, Trenton, N. J.



Chemical Porcelain

Claiming strength, chemical stability, non-porosity and resistance to abrasion and corrosion combined to an extent unknown to any other material. A range of pieces available, said by the manufacturer to offer opportunity for more efficient and economical handling of chemicals, includes evaporating dishes, kettles, funnels, piping, a light-weight super-strength vacuum filter, and a porcelain roller for paper coating, textile dyeing, etc., polished to 0.001 in. surface accuracy. Special shapes and bodies to meet particular requirements supplied on order. Bulletin 165 describing the material and its characteristics available. Lapp Insulator Co., Inc., LeRoy, N. Y.

Portable Printer

For making fast, positive prints from tracings of drawings, plans, specifications, etc. Using a special sensitized paper, positive contact prints up to 12x18 in. in size can be made for less than 2 cents per print. Prints can be made in from 1 to 5 min., dry and ready for use. This process will give a white background with blue lines using Ozalid dry process paper. Black line or red line paper is also available. Printer measures 22x16x11 in., weighs less than 33 lb., and is simple to operate. Bulletin available. Electronic Products Mfg. Corp., 208 W. Washington St., Ann Arbor, Mich.

Miniature Ball Bearings

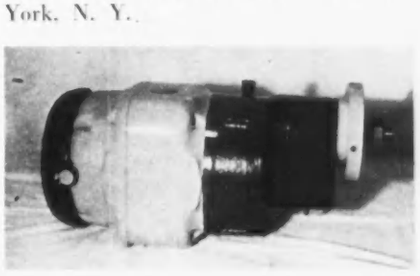
High precision miniature bearings of the true radial type, designed for such applications as fine precision instruments and similar uses where the utmost in anti-friction property is essential. Available in sizes down to $\frac{1}{8}$ in. O.D. and can be made as small as $\frac{1}{16}$ in. O.D. Special literature available. Split Ball-bearing Corp., Lebanon, N. H.

Strip Heaters

For operation at sheath temperatures as high as 1,200 deg. F. Heaters are inclosed in porcelain-enameled steel casings, providing resistance against rust and corrosion. General Electric Co., Schenectady, N. Y.

Geared Head Motors

A line of precision-built, geared head motors designed for industrial uses where a compact motor and spindle head in one unit assembly could be utilized to advantage as a direct power head drive. The built-in precision spindle unit features an off-set shaft of the parallel type in a gear housing of compact design. Spindle and gear housing incorporates integrally built-in seals to protect the assembly from all foreign matter. Motors are available in sizes from 1 to 5 hp. for various current requirements and with standard spindle speeds of 1,150, 1,725, 2,300, 3,450 and 5,600 r.p.m. Spindle nose ends of various types are available. Portman Machine Co., 2236A Bathgate Ave., New York, N. Y.

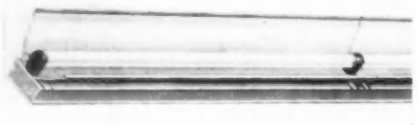


Foot Control Switch

This double-pole, single-throw switch permits starting or stopping the machine while the operator's hands are free to handle the work on lathes, grinders, saw benches or drill presses. The drive motor will run only while the switch is closed by foot pressure; removal of the foot from the switch will bring the motor to a stop. Rated 12 amp. at 125 volts and 6 amp. at 250 volts. The Leeds Electric & Mfg. Co., 1840 Broad St., Hartford, Conn.

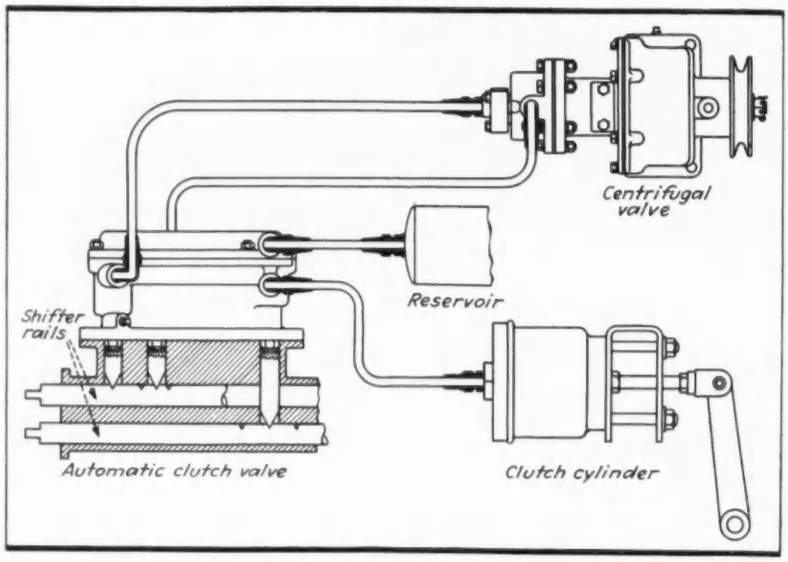
Fluorescent Reflector

A concentrating type reflector especially designed for applications of the fluorescent lamp and strip. It is designed to incorporate the advantages of the parabola for effective and efficient control of light and has an adjusting feature which permits the reflector to be set in any one of three positions. Reflector is manufactured in lengths corresponding to the three lengths of the fluorescent lamp, namely 18, 24 and 36 in. Wiremold Co., Hartford, Conn.



Aluminum Paints

Ready-mixed Permite aluminum paints for product finishing. Includes a quick drying aluminum paint that will dry to touch in 10 to 15 min. for applications on wood and metal products, a nitrocellulose spraying lacquer that will dry to touch in 5 to 10 min., a fast drying spraying lacquer which will dry to touch in ½ to 2 min. and hard dry in 3 to 5 min., a short oil synthetic grade of aluminum paint intended for use where very smooth and brilliant finish is desired, and a dipping type which can be air dried or baked at 300 deg. F. Paint Div., Aluminum Industries, Inc., Cincinnati, Ohio.

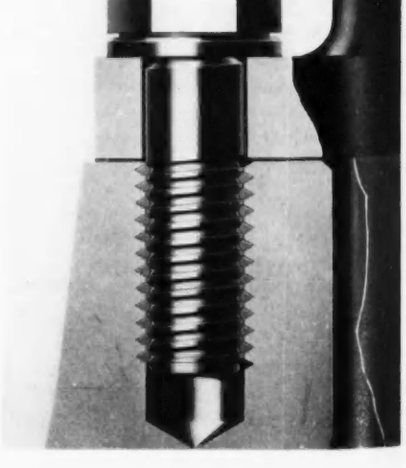


Air Clutch Control

For the remote control of clutches, especially designed for motor vehicles. Control consists of an air cylinder connected directly to the clutch throw-out lever so as to disengage the clutch when sufficient air pressure is supplied. Air pressure is provided from the normal braking system through an air valve which is controlled by a centrifugal governor driven by the engine. Centrifugal valve is adjusted to feed sufficient pressure to the air cylinder to hold the clutch released, at idling speed, and automatically decreases the pressure in the air cylinder in direct proportion to increased engine speed, thus giving preselective first or reverse gears. When engine is accelerated on starting, pressure in the clutch cylinder is reduced, permitting clutch to engage, engagement taking place in exact proportion to engine acceleration. If engine acceleration is excessive clutch engagement tends to become too rapid thus slowing down the engine which automatically increases the air pressure, insuring smooth engagement and full engagement when the speed of engine equals the speed of drive shaft. At 1,000 r.p.m. engine speed all air pressure is released from clutch cylinder. In shifting from first to second operator need only release the accelerator, initial movement of gear lever operating another valve known as the clutch valve which furnishes air pressure to clutch cylinder, completely releasing clutch for shifting operation. Clutch valve permits double-clutching by momentarily stopping shift lever in neutral position which releases the pressure from the clutch cylinder causing the clutch to engage. Movement of shift lever from neutral to second again actuates clutch valve, disengages clutch, and automatically reengages clutch at completion of the shift. Shift from second to third speed is accomplished in the identical manner. By virtue of its method of operation, no load can stall the engine. Bendix-Westinghouse Automatic Air Brake Co., Pittsburgh, Pa.

Aero-Thread Screw System

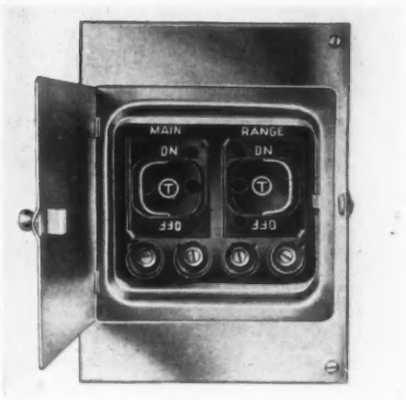
Developed primarily for use in the aircraft industry, this "Aero-thread" screw system uses a spirally wound insert or bushing of precision formed, high tensile, bronze spring wire. This insert fits into the tapped hole by screwing it into the threads and is designed so that when once installed it becomes a fixed part of the tapped hole. Thus the stud or capscrew thread is only in contact with the spiral bronze insert instead of bearing against the metal of the tapped hole. Thus this thread system permits the unrestricted use of capscrews and removable screw fastenings



in soft metals such as aluminum or magnesium without the danger of wearing the tapped hole oversize through repeated disassemblies. "Aero-thread" capscrews available in heat-treated alloy steels and heat-treated aluminum. Available in all standard sizes from $\frac{3}{16}$ to $\frac{3}{4}$ in. inclusive, together with all necessary taps, inserts and tools. Booklet available. Air Associates, Inc., Garden City, N. Y.

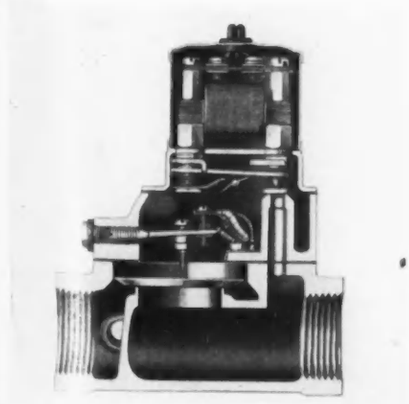
Combination Range and Entrance Switch

An improved 60 amp. range and entrance switch, No. 2924–4, claimed to be more compact in design and easier to wire. Finished in aluminum, both inside and out. Surface type provided standard with a separate fuse door hinged to front making possible a semi-flush installation. Circular No. 311 available. Trumbull Electric Mfg. Co., Plainville, Conn.



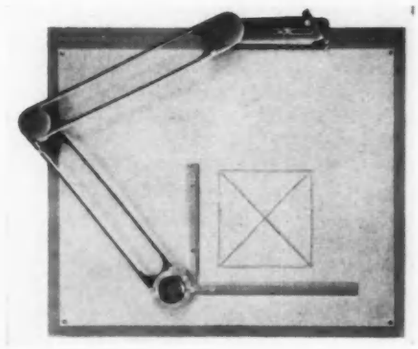
Slow-Acting Gas Valves

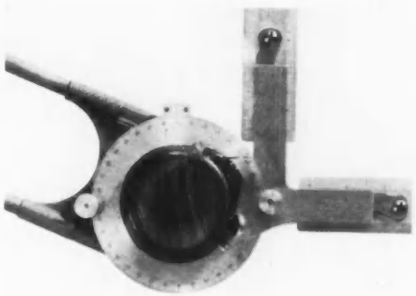
Provide a soft ignition at low flame followed by a gradual opening to full flame, in gas-fired furnaces. Valves incorporate a snap primary flow of adjustable volume, a hesitation period, allowing time for uniform draft to be established, followed by slow opening to full capacity. Closing cycle is snap-acting. Available in two sizes, $\frac{3}{4}$ and 1 in. pipe tap, and operate on 20 volts. Julien P. Friez & Sons, Div. of Bendix Aviation Corp., Baltimore, Md.



Drafting Machine

An arm that completely incloses bands and working parts to minimize accumulation of dirt and to protect the draftsman, constitutes a major improvement in the Model 77 drafting machine. An improvement of equal importance is the full-vision protractor, located above the arm, giving unrestricted vision and greater convenience of operation and control. A secondary 360 deg. protractor movement has been added to make possible the setting of the protractor to any angle on the drawing. Then from the new base line, the 30, 45, 60 and 90 deg. stops can be used or any graduation read directly. This secondary 360 deg. rotating element is operated by two thumbscrews. Both protractor and arm are made light in weight, which reduces inertia and makes possible easier setting of the machine to an exact point. Universal Drafting Machine Co., Cleveland, Ohio.



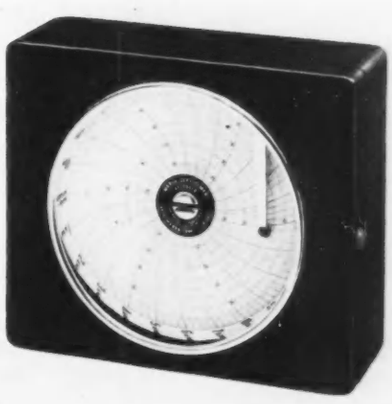


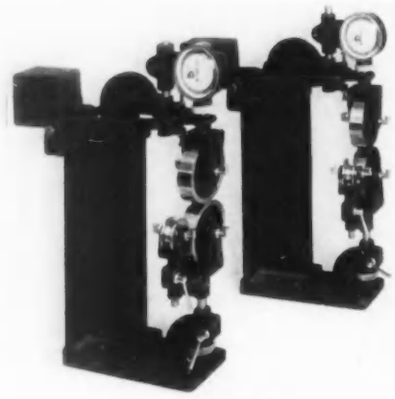
For Reproducing Tracings

Known as Ozalid light sensitized foil, this cellulose acetate transparent sheet is used for reproducing tracings. It can be handled in daylight and uses the Ozalid dry development process. One outstanding feature is that the tracing reproduced has greater contrast than the pencil drawing or tracing from which it is made. Thus the prints subsequently made from the sensitized foil are clearer and sharper than those which would be produced directly from the original tracing. This sensitized foil has four outstanding applications: (1) to rejuvenate worn or torn tracings, (2) to make usable tracings wherein the lines are too faint to permit prints directly, (3) the duplication of valuable tracings for separate filing, (4) to reproduce the major part of a tracing, blocking out portions not desired in order to be able to quickly make another tracing wherein some of the details must be altered. The Ozalid foil duplicate is made directly, eliminating the necessity of negatives. The material, cellulose acetate, does not shrink or stretch and is flexible and durable. Available in two thicknesses of sheet, in cut sheets or in rolls. Standard rolls are 15 yards long. Cost of the material is said to be not more than, or slightly less than, high grade tracing cloth. Ozalid Corp., 354 Fourth Ave., New York, N. Y.

Recording Thermometer

A low-cost, portable recording thermometer, known as the No. 70 "Serviceman" recorder. It weighs less than 2 lb. and measures 5 x 6 x $2\frac{1}{4}$ in. A bimetallic spiral of advanced design is used in the temperature recorder. Zero adjustment is conveniently made by a screw and the chart is rotated by an accurate, fully adjustable clock movement, wound by a convenient knob extending through the back of the case. The pen arm has a friction hinge which permits it to be swung clear of the chart for quick and convenient chart replacement. A pointer on the dial enables the operator to set the chart at the proper time. A wide variety of charts in Fahrenheit or Centigrade are available covering room temperature, outside temperature, cooling and heating applications. Descriptive literature available. Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.



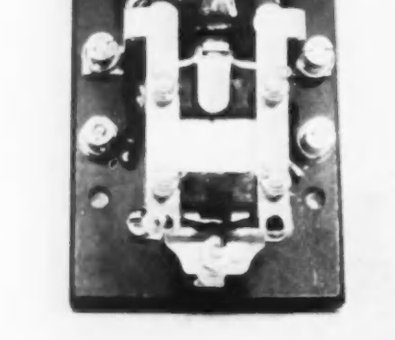


Continuous Measuring Gage

Model 493B-21, for measuring wire or flat material. The roller contacts are made of hardened steel and run on precision roller bearings. They will follow material of reasonably smooth surface at a speed of 1,000 ft. per min. with 4 in. rollers. Greater or lower speeds may be provided for by means of larger or smaller rollers. Pressure of the upper roller can be adjusted to suit requirements by means of the counterweight. The indicator is entirely encased to keep out dust, and is provided with tolerance hands for easy checking. If desired, a recording gage can be mounted in back of the indicator to record variations in thickness, wire break time elapse, etc. Federal Products Corp., 1144 Eddy St., Providence, R. I.

Midget Relay

A line of midget mechanical latch-in electrical reset relays made in both a.c. 110–220 volts, 6 and 3 amp. respectively, and in d.c. 115 volts, 1 amp. They are provided with two coils. When the lower coil is energized, the armature picks up and latches in the energized position. Energizing the upper coil releases the latch allowing the armature to drop out. Relays are supplied with coils for either momentary or continuous duty. No power is required in the coil circuit to hold the armature in either position. They are used in connection with three wire thermostats, pushbuttons, etc. Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa.



Radial Couplings

Specially shaped patented rubber bushings are used in the "Morflex" radial coupling to provide an effective flexing medium for withstanding shock loads and resisting vibration. These rubber blocks are assembled radially, equally spaced, on the steel pins of the yoke or hub member. A two-piece metal housing encases the rubber blocks and also provides for attaching the companion flange to the unit. Coupling is machined to insure perfect balance. Since there is no metal on metal movement, it is fully insulated against noise and electricity and requires no lubrication. Available in various sizes with capacity ratings of from 2 to 37 hp. at 100 r.p.m. Morse Chain Co., Ithaca, N. Y.

Transparent Metal Coating

Known as "Seal-Cote," this protective metal coating is said to withstand the action of sunlight, moisture and climatic changes. It is claimed to have been used successfully with copper, brass, bronze, steel and other metals and has preserved the original finish even when exposed to the weather for at least six months. It may be sprayed or brushed. The Fales Chemical Co., Inc., 545 Fifth Ave., New York, N. Y.

Small Power Motors

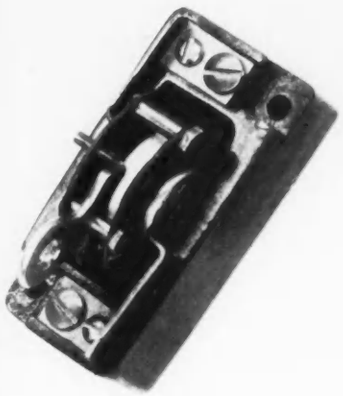
Wound for shaded pole or permanent split capacitor operation and furnished in the sub-fractional sizes. Motor illustrated may be wound for shaded pole operation in sizes from 1/200 to 1/80 hp. It may also be wound for permanent split capacitor operation in sizes from 1/150 to 1/20 hp. at 3,400 r.p.m., and to 1/30 hp. at 1,700 r.p.m. or to 1/50 hp. at 850 r.p.m. When so wound the efficiency is practically double that of the shaded pole motor. Unit measures 3.75 in. square, by 4.75 in. long, plus a $\frac{3}{8}$ in. diam. extending shaft standard length of which is 1.25 in. Can be supplied to mount in any desired position or with resilient base as shown. The small capacitor may be mounted on the motor or separately. Start torque is slightly above full load and maximum running torque about four times full load. Standard wool-fed oiled sleeve bearings are used. The Ohio Electric Mfg. Co., 5917 Maurice Ave., Cleveland, Ohio.

Vernier-Set Timers

Series 2800, providing accurate and visible timing adjustment. By employing the Vernier principle, the time cycle can be set accurately to within a split scale division. The desired adjustment is maintained with no locking device required. With Type 2803 four arrangements of load circuits are possible. Timers are especially well adapted to automatic machinery, to molding and extrusion presses, to the purging of gas fired ovens, and to the timing of furnace operation. Automatic Temperature Control Co., 34 E. Logan St., Philadelphia, Pa.

Switching Mechanism

A general purpose switching mechanism employing the G.E. "mercury button" and designed for installation on electric appliances. For flexibility in mounting, the switching mechanism is



made with the mercury button placed at eight different angles so that it may be mounted in any 45 deg. position in the vertical plane. The mercury button consists of mercury-to-mercury contacts inclosed in two special alloy metal disks which are glass-sealed on a ceramic barrier. Hydrogen gas in the button prevents oxidation of mercury and cools and quenches the arc when the circuit is broken. General Electric Co., Appliance and Merchandise Dept., Bridgeport, Conn.

Marine Type Motors

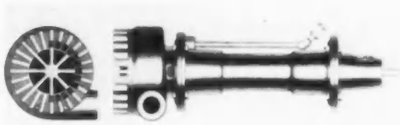
Direct-current, waterproof marine motors having heavy overload capacity, quick starting and stopping characteristics, and capable of withstanding extremes of temperature. Motor frames are of cast steel, split horizontally to provide easy access for inspection and repairs. The armature coils are insulated on the slot portion with mica wrapper; field coils are vacuum impregnated with "Hydrolene Gum"; and a junction box for the entrance of conduit or leaded and armored cable through stuffing tubes is supplied at the split of the frame where the leads are brought out. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electric Meters

Alternating and direct current ammeters, milliammeters, microammeters, voltmeters, single and polyphase wattmeters and pyrometers for panel mounting, both flush and surface models. These new 4-in. square models form a companion to the line of 3-in. square instruments which were placed on the market last April. The 3- and 4-in. round instruments have been on the market many years. Bulletin 48-a available. Roller-Smith Co., 233 Broadway, New York, N. Y.

Coolant Pumps

A series of coolant and lubricant pumps designed especially for use in conjunction with machine tools or auxiliary tanks where the unit must be driven with a flat or V-belt, chain, gear or flexible coupling, or where it is impossible or impractical to mount motorized models. Particularly desirable for use on export or foreign shipments where the electrical characteristics will usually have a tendency to alter the motor speed and therefore the delivery of the unit. Model FV (foreign vertical), illustrated, and the Model FB-V (foreign bracket vertical) are designed in such a way as to be submerged directly into the tank or reser-



voir and to be attached to the side of the tank or machine as required. The FB-V may be suspended by the foot bracket attached to the pump, whereas the F-V would be mounted with the conventional tank brackets and flanges available for use with all other Pioneer types of vertical pumps. Model F-B is built to mount on the side of a coolant tank or machine pedestal for close coupled installation. All of the units are built in capacities up to 175 gal. per min. and pressures up to 53 lb. per sq. in. Pioneer Engineering & Mfg. Co., 31 Melbourne Ave., Detroit, Mich.

Ultra-Opaque Enamels

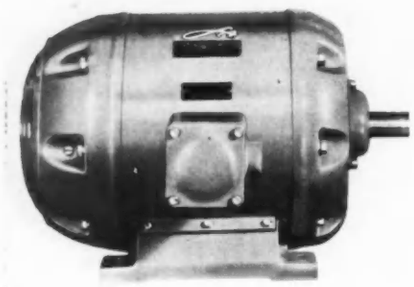
Providing increased opacity for porcelain enamel finishes. Designated as Ultrapaque No. 1313, these enamels are said to afford a saving of 40 per cent in cover coat requirements. Other advantages claimed are increased resistance to mechanical shock and deflections, greater resistance to scratching, practical elimination of chipping, and the production of enameled sheets that shear neatly with no chipping back from the edges. Ultrapaque enamel frit is supplied in powdered form, pre-ground so that 90 per cent of it passes through a 200-mesh sieve. Ferro Enamel Corp., Cleveland, Ohio.

Pencil Drafting Cloth

Known as "Pencil-tex," similar in appearance to fine tracing cloth, it has a patented velvety surface with a remarkable affinity for pencils of all degrees of hardness. Even the use of the hardest pencil is said to leave a sharp, uniform, ink-dense line. Prints made through Pencil-tex are claimed to be completely without the characteristic fuzzy line and foggy appearance of blueprints made from ordinary pencil drawings. Frederick Post Co., Box 803, Chicago, Ill.

Adjustable Thermoswitch

Designed for insertion into a closed liquid or gas system by means of a ½ in. standard pipe thread. Where liquid or gas has no corrosive action on brass or silver solder a well is unnecessary. Available either normally open or normally closed. Adjustment is by means of a screw which changes adjustment 80 deg. F. per full turn of the screw. Change adjustment of 20 deg. F. per full turn is obtainable on special order. Adjustable operating range is from —50 deg. to 400 deg. F. Especially designed for cycle controls in sterilizing and pasteurizing equipment, limit switches on furnaces and hot water heaters, and for electrically heated platens on molding presses. Liquid or steam heated platens are readily controlled by using a solenoid valve in the supply line. Descriptive catalog available. Fenwal Incorporated, Ashland, Mass.



Explosion-Proof Motors

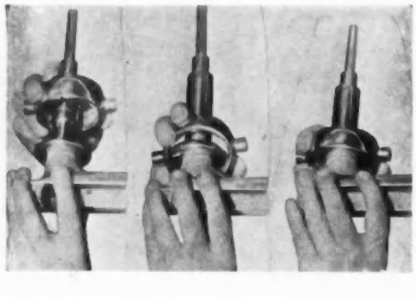
A line of a.c. and d.c. explosion-proof motors which, according to the manufacturer, makes possible a new high in electric motor dependability convenience, long life and safety. Features claimed for the motor include rugged, heavily reinforced cast iron and steel construction, cartridge type bearings, reinforced end bells, aluminum alloy fan, smooth streamlined shape, double protected insulation, designed to give dependable performance under the most severe operating conditions. Motors are available in a wide variety of both mechanical and electrical characteristics. Descriptive Bulletin 508E available. The Louis Allis Co., Milwaukee, Wis.

Synthetic Enamels

A line of "high-speed" synthetic enamels, known as Polydur enamels, with very short baking schedules. Polydur enamels set out of dust in a few minutes. Their baking schedules depend upon the temperature employed, but at 325 deg. F. they bake to a fine finish without discoloration in 15 min. The finish is said to be durable and resistant to marring, moisture, and ordinary household chemicals. Finishes are supplied in white and all colors, for spraying or dipping. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Removable Union Nut

To meet the sanitary ruling that all unions must be removed from thermometers and recorders for cleaning, especially in dairies. Nut is designed to eliminate necessity of redesigning thermometers and expense of carrying a special item for a particular industry. Nut may be removed by simply slipping it over the ferrule or collar of the thermometer as shown in the illustration. Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

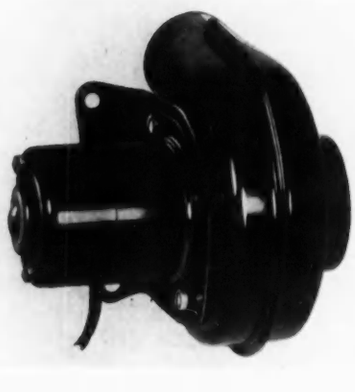


Time Totalizer

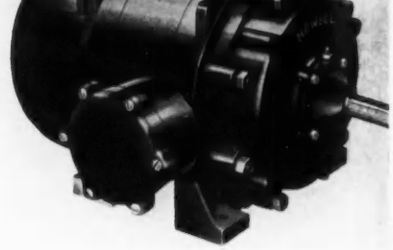
For automatically measuring the "on time" of alternating current circuits. The time totalizer consists of number wheels geared to a synchronous motor so that they record time in hours and tenths of hours. When connected in parallel with a motor, radio, lighting circuit or other alternating current circuit, the instrument automatically accumulates the total "on time." Unit is inclosed in a dust proof case with adequate provision for mounting and convenient wiring. Production Instrument Co., 702-10 W. Jackson Blvd., Chicago, Ill.

Motor Driven Blowers

Built in either single or double outlet types, with quiet, multi-blade fans, designed to give continuous service at constant speed. Twin blowers are available in 115 and 230 volt a.c. models, with free air discharge of 120 cu.ft. per min. Single blowers are available in 60 cycles a.c., 115 and 230 volt models with either right or left-hand delivery. The 25 cycle a.c., the a.c.-d.c. 115 and 230 volt, and the d.c., including 6, 12 and 32 volt models have right-hand delivery only. All give a free air discharge of 60 cu.ft. per min. The 60 cycle a.c. models are powered by Delco Appliance shaded pole induction motors. On double blowers, the motor is in the center, while on single blowers it can be at either the right or left of the fan. Delco Appliance Div., General Motors Sales Corp., Rochester, N. Y.



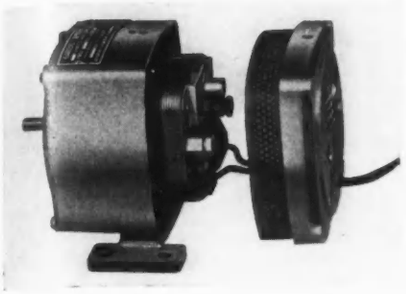
Explosion-Proof Motor



An extension to the line of Type EKBB polyphase and Type EKCI single-phase, explosion-proof motors, ¾ hp. up to 40 hp. According to the manufacturer, tests have proved that this design will withstand the explosion of an inflammable substance inside the motor and prevent the flames produced by such an explosion from reaching the surrounding atmosphere; also that the heat capacity is great enough to prevent the motors, even under abnormal conditions, from reaching a temperature high enough to ignite surrounding gases. Illustration shows a Howell explosion-proof motor with a totally inclosed, fan-cooled frame. Howell Electric Motors Co., Dept. I, Howell, Mich.

Geared Head Motors

"Barcol" motors now available with both open and inclosed type gear reductions. The open type reduction is supplied with four different gear ratios, designed to carry the maximum output the largest motor will develop. These gear reductions are supplied for two sizes of undirectional and three sizes of reversible motors. Outputs vary from 0.0002 to 0.0052 hp. at the output shaft. The inclosed gear reduction, illustrated, was developed to meet the demand for a variety of speeds and outputs with interchangeable mounting. Outputs vary from 0.0003 to 0.0035 hp. Motor inclosure provides the necessary ventilation for safe operating temperatures. The gears are entirely inclosed, and wick



oilers with sufficient capacity for six months continuous operation are provided for lubricating all bearings. Data Sheet No. M-31 available. Barber-Colman Co., Rockford, Ill.

Ball Bearing Swing Joints

Designed for operations requiring small, leak-proof and pressure-tight swing joints. They will give full 360 deg. rotation without binding. Double rows of hardened steel ball bearings serve both to carry the radial load and to keep the packing element compressed by maintaining a pre-regulated thrust load upon it. High-pressure joints are of steel construction, tested to 4,000 lb., low-pressure joints are made of brass or malleable iron, tested to 300 lb. Joints can be used for fluids, gases or steam. Available in $\frac{3}{8}$ and $\frac{1}{2}$ in. sizes and in five styles for various rotating motions, furnished with standard thread type connections. Descriptive bulletin available. Chiksan Oil Tool Co., Ltd., Fullerton, Calif.

Infra-Red Ray Lamps

An improved infra-red ray lamp, known as the "Dritherm," for radiant drying and heating purposes. Features claimed for these lamps include long burning life in proportion to high efficiencies obtained, uniformity of filament materials as well as placement of carbon filament within the bulb, and rugged construction to minimize breakage. North American Electric Lamp Co., 1014 Tyler St., St. Louis, Mo.

Manufacturers' Publications

ALLOYS—Haynes Stellite Co., Unit of Union Carbide & Carbon Corp., Kokomo, Ind. "Products of Haynes Stellite Company," 16 pages, 8½x11 in. Containing tables of physical, mechanical and chemical properties of the principal Haynes Stellite alloy products, together with a brief description of each product.

ALLOY STEEL—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. Bulletin on "Ry" alloy steel, developed to meet the demand for an oil hardening steel which, when heat-treated, would develop high hardness and deep penetration, and have minimum distortion and freedom from cracking.

AMPCO METAL—Ampco Metal, Inc., Milwaukee, Wis. Catalog No. 21, second edition revised, 32 pages, 8½x11 in. Detailed description of Ampco metal alloys, physical properties and typical application.

BEARINGS—Johnson Bronze Co., New Castle, Pa. Catalog 390, 72 pages, 8½x11 in. A complete, illustrated catalog listing their line of general purpose bearings, electric motor bearings, graphite bearings, solid and hexagon bars, lead base and tin base products, etc.

CASTINGS—Smith Steel Foundry Co., 1320 S. First St., Milwaukee, Wis. Folder 8½ x11 in. Covering their stainless steel castings, showing a series of typical castings, and listing six commonly used Smith alloys to meet a wide range of requirements.

CONTROL VALVES—The Bristol Co., Waterbury, Conn. Bulletin 514, 20 pages. Covering their line of air-operated, synchro-valves for automatic control, including information on principles of design, outstanding features, and directions for ordering or specifying the valves.

CONVEYORS—Mathews Conveyor Co., Ellwood City, Pa. Catalog HB39, 384 pages, spiral bound, 4¾x6½ in. Containing complete engineering data on the Mathews line of conveyors.

DIESEL ENGINES—Caterpillar Tractor Co., Peoria, Ill. Folder, 8¼x10¾ in. showing a variety of applications for "Caterpillar" diesel engines.

"ELECTRICAL EQUIPMENT FOR CRANES"—Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis. Bulletin C-5. A discussion of the electrical equipment necessary for modern crane operation.

GEARS—The Ohio Gear Co., 1333 E. 179th St., Cleveland, Ohio. Catalog 39, 136 pages, spiral bound, 4¾x7¾ in. Illustrated catalog listing their complete line of speed reducers, gears, sprockets, chains, etc.

HEATERS—Harold E. Trent Co., 618-640 N. 54th St., Philadelphia, Pa. Folder containing data and information on their electric vane strip heaters.

LEDLOY STEEL—Joseph T. Ryerson & Sons, Inc., 16th & Rockwell Sts., Chicago, Ill. Bulletin describing the new lead-bearing open-hearth steels, available in a wide range of analyses. Bulletin includes results of actual machining tests.

LINESTARTERS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet B-2131, "4 Points to Check in Motor Starters," 8 pages, 8½x11 in. Covering their combination linestarters, consisting of the "De-ion" linestarter and the Nofuze "De-ion" circuit breaker.

METERS—Bailey Meter Co., Cleveland, Ohio. Bulletin 194-A, 16 pages, 7¾x10½ in. Details on the "Bailey Synchro-Meter," a simple electrical mechanism which accurately transmits and indicates, records or integrates the measure of any factor, such as flow, level, pressure and temperature at a distant point. Wiring diagrams illustrating the principle of operation included.

MOLDING POWDER—Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia, Pa. Descriptive details, properties and characteristics of Crystalite, a thermoplastic compression molding material.

MOTORS—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin 1196, "Making Machine Tools Earn Their Way With Allis-Chalmers Lo-Maintenance Motors," 16 pages, 8½x11 in. Well-illustrated with a variety of installation photographs showing applications of their motors and the progress made in the applying of motors to machine tools.

MOTORS—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Leaflet 2125-C, 4 pages, 8½x 11 in. "Explosion-Proof Motors." Includes numerous constructions and installation views, showing their explosion-proof motors in a variety of hazardous applications.

MOTORS—Diehl Mfg. Co., Elizabethport, N. J. Price List and Catalog 39, 26 pages, 8½x11 in. Containing useful price information and application data on motors, generators, motor-generator sets, ventilating equipment, grinders, etc., arranged in simplified form for quick and easy reference.

MOTORS—Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles, Calif. Bulletin 146, 8½x11 in. Descriptive details and applications of their "Slo-Speed" motors. Bulletin 148 describes their pipe-ventilated motors.

MOTORS—The Louis Allis Co., Milwaukee, Wis., Bulletin 515, 8x10½ in. Motor Application Chart, lists 26 different types of motors and checks the proper type recommended for about 50 standard applications. Also analyzes the starting, maximum and full load torque characteristics of these motors.

speed regulation, per cent of slip, and other information compiled for ready reference.

MOTORLESS SPEED REDUCERS—Janette Mfg. Co. Inc., 556-558 W. Monroe St., Chicago, Ill. Bulletin 22-33. Descriptions, capacities and dimensions of their line of worm gear reducers without motors.

NICKEL—The International Nickel Co., Inc., 67 Wall St., New York, N. Y. An eight-page index to the numerous bulletins published by this company under the general subject, "Nickel in the Brass Foundry."

PYROMETERS—The Bristol Co., Waterbury, Conn. Catalog 1452, 36 pages. Presenting complete information on their line of wide-strip pyrometer recorders and controllers.

PLASTIC MATERIALS TESTING MACHINES—Tinius Olsen Testing Machine Co., 500 North 12th St., Philadelphia, Pa. Bulletin 17, 12 pages, 8½x11 in. Illustrating and describing modern machines for testing plastic materials.

RADICON REDUCERS—Thomas Prosser & Son, 120 Wall St., New York, N. Y. Catalog, 20 pages, 9x12 in. Detailed description of the Radicon worm reducer; performance charts; types, sizes and mounting dimensions.

RESISTORS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Leaflet 1734-B. Containing instructions for the manufacture and care of grid type resistors for d.c. and a.c. motors, and a suggested auxiliary set of renewal parts to be carried in stock by the user.

SCREWS AND BOLTS—The H. M. Harper Co., 2620 Fletcher St., Chicago, Ill. 1939 Catalog and Price List, 72 pages, spiral bound, 5¾x8¾ in. Covering their line of non-ferrous and stainless steel bolts, nuts, screws, washers and accessories.

SPEED REDUCERS—Nuttall Works, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa. Descriptive Data 3620, 12 pages, 8½x11 in. Types SH and DH speed reducers, used with all prime movers such as electric motors and gas, oil or diesel engines, and suitable for any application where economy of power transmission and exact speed reduction are important, are described and illustrated.

SPONGE RUBBER—The Sponge Rubber Products Co., Derby, Conn. Catalog, 16 pages, 8½x11 in. Covering some of their standard and special Spongex products and their uses.

SPRAY NOZZLES—Supreme Electric Products Corp., 99 Mt. Hope Ave., Rochester, N. Y. Leaflet describing features of their spray nozzles, data for proper selection, and typical applications.

TRANSFORMERS—Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago, Ill. Spring-Summer edition of their complete transformer catalog 400-CX, superseding 400-AX and 400-C.

Books and Bulletins

Fractional Horsepower Electric Motors

CYRIL G. VEINOTT.—*315 illustrations, 22 tables, 431 pages, 6x9 in. Black clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.50.*

The author describes thoroughly and clearly in this volume the several types and kinds of fractional horsepower motors that are available, what makes them run, what they will do, and how to repair them. In his description of each of the major types is included an explanation of the principles of operation, the forms of construction and the speed torque characteristics, accompanied with schematic and detailed diagrams of connections.

The book should be of much interest to those who use, manufacture or design fractional horsepower motors, as well as to men engaged in motor installation, maintenance and repair work.

The Chemical Formulary

H. BENNETT, *Editor-in-Chief.—Vol. IV, 600 pages, 6x9 in. Clothboard covers. Chemical Publishing Co., Inc., 148 B. Lafayette St., New York, N. Y. Price $6.00.*

This collection of practical commercial formulas and recipes for making thousands of products will be found a source of extremely useful information to almost anybody. Precise directions are given for formulating a wide variety of chemical preparations ranging from adhesives and cosmetics to inks, paints, waxes, cleaners, lubricants and similar preparations. Typical formulas include glass marking inks, innumerable types of adhesives and binders, metal fillers, photographic formulations, metal polishes, abrasives, soaps and cleaners, and many others.

Machinery's Handbook

ERIK OBERG AND F. D. JONES. *Tenth Edition. 1,815 pages, 4½x7 in. Flexible covers. Published by The Industrial Press, 148 Lafayette St., New York, N. Y. Price $6.00.*

The tenth edition of this widely used handbook is 224 pages larger than the preceding edition. The additional pages were made necessary in order to present properly important new and revised material relating to engineering and manufacturing standards, machine shop data, and general information of interest to all who are engaged in designing and building machinery and mechanical equipment.

Mathematical tables and other standard features of earlier editions have been maintained. Divided into 134 main divisions, it is difficult to select for special mention those features which are of most importance. Some of the many subjects covered in the new material are mounting dimensions, horsepower and speed ratings for motors of different types; American gage standards; screw thread standards; pin and chordal methods for checking gear sizes; standard tolerances for forging; standards, symbols and abbreviations used for drawings; selection of lubricants for bearings; steels, brasses, bronzes and nonmetallic materials for gearing.

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Proceedings of the Third Annual Forum of the Porcelain Enamel Institute

288 pages, 6x9 in. Published by the PORCELAIN ENAMEL INSTITUTE, *612 N. Michigan Ave., Chicago, Ill. Price $2. Upon request, a copy of the Proceedings of the First Annual Forum and the Second Forum will be included without charge with any order for the present volume.*

A complete record of the papers presented and verbatim reports of the discussions that followed during the Third Annual Forum meetings of the Porcelain Enamel Institute, held at the University of Illinois last October.

The subject matter covers a multitude of current problems in the fields of enameling shop practice, laboratory testing, and the use of iron and steel for enameling stock.

U.S.S. Carilloy Steels

214 pages, 6¼x9¼ in. Blue clothboard covers. Published by the CARNEGIE-ILLINOIS STEEL CORP., *Pittsburgh, Pa. or Chicago, Ill. Price $1.00.*

A complete handbook on alloy steels. It contains a list of steel making elements, their commercial uses, and their effect in steel and the types of steel containing them. There are complete lists of S.A.E. alloy steels, giving their analyses and some of their commercial applications.

Book is fully illustrated with charts, some of which have not been published heretofore. It also contains numerous pictures of alloy steel manufacturing processes, methods of testing in the metallurgical laboratories of the Carnegie-Illinois Steel Corporation, and of the equipment of the research laboratories of the United States Steel Corporation.

Multi-Speed Motors—I

Winding Connection Diagrams for Constant Horsepower

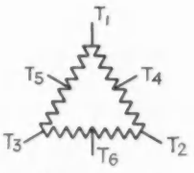
W. S. RIGBY
Engineering Department, Wagner Electric Corporation

FOR A DISCUSSION of types, characteristics and speeds obtainable in multi-speed polyphase squirrel cage induction motors see article on pages 200-2 of this number, "Multi-Speed Motors—Speeds Available, Characteristics and Classifications," by W. S. Rigby.

Multi-speed key diagrams for old and new standards are shown on this and the next page for single-winding and two-winding three phase constant horsepower motors with winding connections.

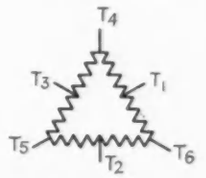
Additional diagrams covering multi-speed constant torque and variable torque motors will be presented in the Reference Book Sheets in the June *P. E.* number.

MULTI-SPEED MOTORS, CONSTANT HORSEPOWER, KEY DIAGRAMS



Single winding - Two speed
N.E.M.A. MG.6-41 Fig.8 1930

Speed	L_1	L_2	L_3	
Low	T_4	T_5	T_6	T_1 T_2 T_3 Together
High	T_1	T_2	T_3	T_4 T_5 T_6 Open



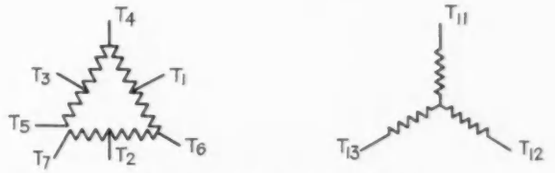
Single winding - Two speed
A.S.A. C-6 3.720 1938

Speed	L_1	L_2	L_3	
Low	T_1	T_2	T_3	T_4 T_5 T_6 Together
High	T_4	T_5	T_6	T_1 T_2 T_3 Open

Two winding - Three speed
N.E.M.A. MG.6-41 Fig.8-1930

	Speed	L_1	L_2	L_3	
*	Low	T_4	T_5	T_6	T_1 T_2 T_3 T_7 Together
**	Second	T_{11}	T_{12}	T_{13}	
*	High	T_1	T_2	T_3 T_7	

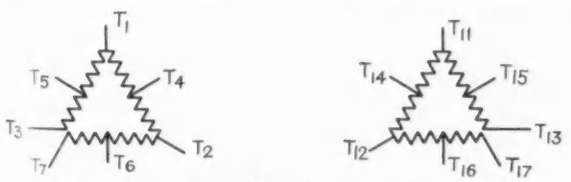
Terminals not listed must be left open
** Low speed half of high speed



Two winding - Three speed
A.S.A. C-6 3.720 1938

	Speed	L_1	L_2	L_3	
*	Low	T_1	T_2	T_3	T_4 T_5 T_6 T_7 Together
**	Second	T_{11}	T_{12}	T_{13}	
*	High	T_4	T_5 T_7	T_6	

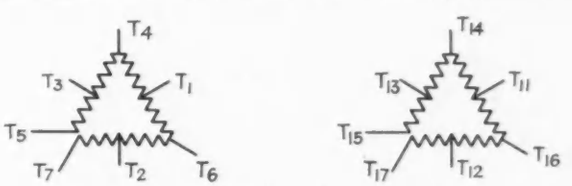
Terminals not listed must be left open
** Second speed between low and high



Two winding - Four speed
N.E.M.A. MG.6-41 Fig.8 1930

Speed	L_1	L_2	L_3	Together
Low	T_4	T_5	T_6	T_1 T_2 T_3 T_7
Second	T_{14}	T_{15}	T_{16}	T_{11} T_{12} T_{13} T_{17}
Third	T_1	T_2	T_3 T_7	None
High	T_{11}	T_{12}	T_{13} T_{17}	None

Terminals not listed must be left open



Two winding - Four speed
A.S.A. C-6 3.720 1938

Speed	L_1	L_2	L_3	
Low	T_1	T_2	T_3	T_4 T_5 T_6 T_7 Together
Second	T_{11}	T_{12}	T_{13}	T_{14} T_{15} T_{16} T_{17} Together
Third	T_4	T_5 T_7	T_6	
High	T_{14}	T_{15} T_{17}	T_{16}	

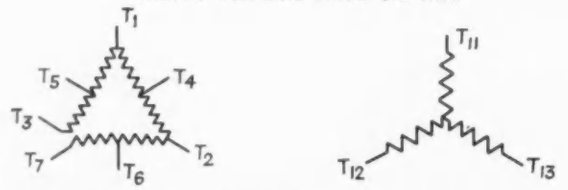
Terminals not listed must be left open

MULTI-SPEED MOTORS—

Winding Connection Diagrams for Constant Horsepower

TWO WINDING - THREE SPEED, THREE PHASE, CONSTANT HORSEPOWER

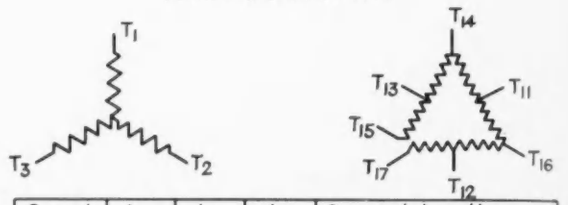
N.E.M.A. BUL.110 PAGE 612 1926



	Speed	L_1	L_2	L_3	Connect together
	Low	T_{11}	T_{12}	T_{13}	None
*	Second	T_4	T_5	T_6	T_1 T_2 T_3 T_7
*	High	T_1	T_2	T_3 T_7	None

* Second speed half the high speed

A.S.A. C-6 3.725 1938

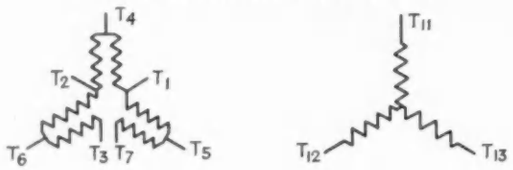


	Speed	L_1	L_2	L_3	Connect together
	Low	T_1	T_2	T_3	None
*	Second	T_{11}	T_{12}	T_{13}	T_{14} T_{15} T_{16} T_{17}
*	High	T_{14}	T_{15}	T_{16} T_{17}	None

Terminals not listed must be left open

TWO WINDING - THREE SPEED, THREE PHASE, CONSTANT TORQUE

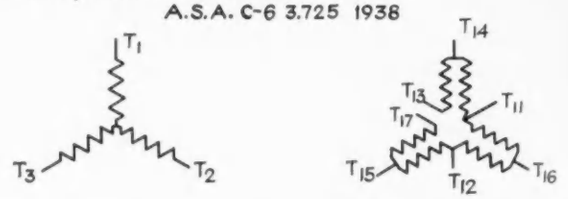
N.E.M.A. BUL. 110 PAGE 612 1926



	Speed	L_1	L_2	L_3	Connect together
	Low	T_{11}	T_{12}	T_{13}	None
*	Second	T_1	T_2	T_3 T_7	None
*	High	T_4	T_5	T_6	T_1 T_2 T_3 T_7

* Second speed half the high speed

A.S.A. C-6 3.725 1938

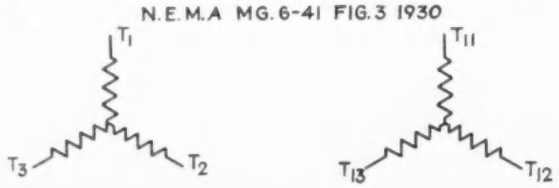


	Speed	L_1	L_2	L_3	Connect together
	Low	T_1	T_2	T_3	None
*	Second	T_{11}	T_{12}	T_{13} T_{17}	None
*	High	T_{14}	T_{15}	T_{16}	T_{11} T_{12} T_{13} T_{17}

Terminals not listed must be left open

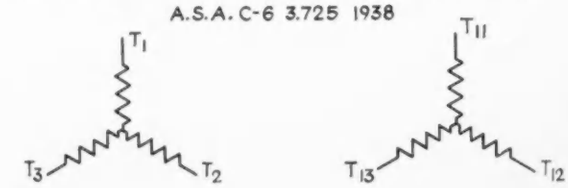
TWO WINDING - TWO SPEED - THREE PHASE - CONSTANT TORQUE - VARIABLE TORQUE - CONSTANT HORSEPOWER

N.E.M.A MG. 6-41 FIG. 3 1930



Speed	L_1	L_2	L_3	
Low	T_1	T_2	T_3	T_{11} T_{12} T_{13} Open
High	T_{11}	T_{12}	T_{13}	T_1 T_2 T_3 Open

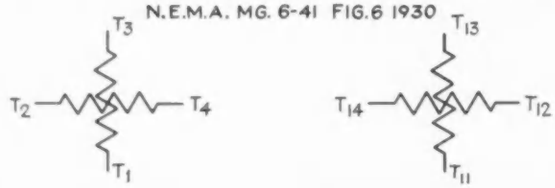
A.S.A. C-6 3.725 1938



Speed	L_1	L_2	L_3	
Low	T_1	T_2	T_3	T_{11} T_{12} T_{13} Open
High	T_{11}	T_{12}	T_{13}	T_1 T_2 T_3 Open

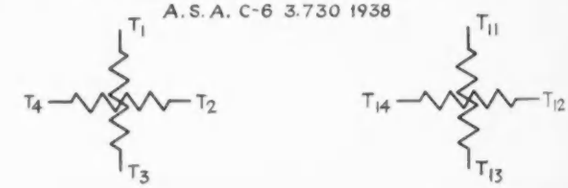
TWO WINDING - TWO SPEED - TWO PHASE - CONSTANT TORQUE - VARIABLE TORQUE - CONSTANT HORSEPOWER

N.E.M.A. MG. 6-41 FIG. 6 1930



Speed	L_1	L_2	L_3	L_4	
Low	T_1	T_2	T_3	T_4	T_{11} T_{12} T_{13} T_{14} Open
High	T_{11}	T_{12}	T_{13}	T_{14}	T_1 T_2 T_3 T_4 Open

A.S.A. C-6 3.730 1938



Speed	L_1	L_2	L_3	L_4	
Low	T_1	T_2	T_3	T_4	T_{11} T_{12} T_{13} T_{14} Open
High	T_{11}	T_{12}	T_{13}	T_{14}	T_1 T_2 T_3 T_4 Open